A simple thermostat actuates the face and bypass damper at the blast coil to maintain predetermined temperatures. The opposed action dampers in the intake box are modulated by static pressure regulators to maintain a slightly negative pressure within the plant. Thus the amount of fresh air we temper through our units is directly dependent on the amount of air being exhausted. When our exhaust systems are inoperative, the pressure regulators will set the dampers for 100 per cent recirculation.

Because much of the duct work in the plant required interior protective linings, special emphasis was placed on methods of fabrication and installation. We decided on a modular arrangement with a 10-ft maximum section length. For straight duct work up to 12 in. in diameter, longitudinal joints are of double lock seam construction. Girth joints are of the Van Stone type with flanged ends, slip-on "O" rings and either rubber or asbestos gasketing. The larger duct work and the fittings and transition pieces of all sizes are of welded construction with angle rings welded at the ends for transverse joining. All the sheet metal is supported by wrap-around tension straps without penetration of the duct walls. Capped nipples to accommodate pitot tubes and sampling probes were included in the original fabrication of the duct work. Although the "balanced system" concept was used as a basis for design, we still included a number of blast gates at critical points. Some additional adjustability was achieved by specifying variable pitch sheaves for all fan motor drives.

Finally, if we assume that everything we have talked about is perfectly planned and executed, there still remains the single most important preliminary prerequisite for successful dust control design. Without the judicious selection of process equipment, all subsequent efforts are doomed to dismal failure. If the equipment is wrong, the battle is lost before it has begun. The right selection is not always the more expensive choice.

And here the Industrial Hygiene Engineer, out of his element, must be supported not only by his technically expert co-workers, but also by the members of Management, who in the final analysis must assume responsibility for the success or failure of the complete operation. We of the Beryllium Corporation sincerely feel that our Hazleton Project is just such a culmination of concentrated cooperative effort.

AIR CLEANING ACTIVITY AT OAK RIDGE GASEOUS DIFFUSION PLANT

R. C. Smith
Oak Ridge National Laboratory

Since there are several locations at Oak Ridge Gaseous Diffusion Plant where fluorine is a component of a waste gas, there exists a problem of disposal of this gas in a safe manner. When the fluorine concentration is low or when small flows or short periods of time are involved, such waste gases may be vented to atmosphere. To dispose of this fluorine without the necessity of dumping into the atmosphere, a method of reaction between preheated fluorine and superheated steam has been employed. This method is described by S. H. Smiley and C. R. Schmitt.[1] They investigated this reaction using undiluted fluorine and air-diluted fluorine in concentrations varying from 13 per cent to 75 per cent and determined conditions for maximum conversion of fluorine to hydrogen fluoride.

A reactor in which fluorine gas was consumed in a reaction with oxides of uranium has been described in a paper by Clouse, Dykstra, and Thompson.[2] Though primarily used as a part of a uranium recovery process, it showed one means of reacting fluorine with uranium compound which results in the formation of a useful product and the removal of fluorine from feed gas. In this process, the dry oxide is fed directly to a screw type reactor and is treated at a high temperature with fluorine gas.

The method employing superheated steam was superseded by one using a reactor which not only disposes of the fluorine effectively but also utilizes this gas to form a useful product. Waste gases containing fluorine from several locations are routed to a common point and passed into a reactor. Under the conditions in the reactor the fluorine reaction is quite complete. Over a wide range of fluorine inlet concentration, the outlet gas is free of fluorine, at least to well below 0.5 per cent. Additional information on the details will be forthcoming in reports presently being prepared.

Air sampling data, which might be used to evaluate the effectiveness of the reactor as a means of reducing air pollution are not yet complete. The problem of measuring the quantitative improvement is quite difficult since a change in locations of discharge points was also made. This method is doubly attractive because the product of the reaction is UF_6, a useful material. It may be expected that more data on the effectiveness of this method will be available in the near future.

One of the more widely used methods for disposal of halogen gases, specifically fluorine in this case, is by scrubbing with caustic either in the form of NaOH or KOH. The fluorine is consumed by the caustic and converted to sodium or potassium fluoride. This method can be employed in conjunction with a lime slurry regenerative process whereby the lime slurry is circulated through the caustic scrubber to remove fluorides and regenerate caustic.

Concentrations in the outlet gas are of the order of a few parts per million with any inlet concentrations of fluorine. This same process for fluorine removal from air is completely applicable for HF.

Standard caustic equipment can be used since the corrosion effect of fluoride ion is negligible under the operating conditions employed.

A mass spectrometer especially adapted to the measurement of small amounts of fluorine has been developed. It is particularly adapted to the measurement of fluorine in the presence of UF_6, but its applicability to determination of fluorine in air samples may be inferred from its behavior in the former role. The limit to its capabilities as an air sampler for fluorine is imposed by the presence of the argon isotope Ar^{38} in air to the extent of about 6 ppm. This will impose a background on the fluorine signal measurement approximately equivalent to the signal from fluorine, itself, when the fluorine concentration is 12 ppm. In the presence of UF_6, fluorine sensitivity is still less than 50 per cent of the argon sensitivity, even though improvements in technique, particularly with reference to consumption of fluorine have increased sensitivity to fluorine by a factor of 5. If not in the presence of UF_6, a further relative increase may be expected which will make the fluorine and argon sensitivities approximately the same. Thus the spectrometer may be used to see a few parts per million of fluorine in an air sample, but accurate quantitative results will be limited to cases in which the amount of fluorine exceeds 6 ppm.

The problem of measurement of air contamination by radioactive dust at Oak Ridge Gaseous Diffusion Plant is being attacked by the development of an impaction type air sampler designed to collect dust of particle size 1 μ and larger.[3] It appears that particles of sizes from 1 to 5 μ are more readily deposited in the lungs than those of other size ranges.[4] Small particles (in the order of 0.01 μ to 0.1 μ) are not retained in the lungs and large particles (above 10 μ) do not enter the lungs to comparable extent.

The air sampler being tested at K-25 provides a continuous method of sampling using an oiled moving tape and impaction of dust in air on the tape. The time delay between sampling and counting can be adjusted to be as low as ten minutes. It is designed to collect dust particle sizes of 1 μ and above. Collection efficiency at 1 μ is approximately 90 per cent as determined using samples of UO_3 powder. At 0.4 μ the collection efficiency is about 50 per cent as determined by using samples of UO_2F_2 and UF_6. These are preliminary data.

REFERENCES

1. S. H. Smiley and C. R. Schmitt, Continuous Disposal of Fluorine—Reaction with Superheated Steam, Industrial and Engineering Chemistry, 46, 244, February 1954.

2. R. T. Clouse, J. Dykstra, and B. J. Thompson, Uranium Recovery at the Oak Ridge Gaseous Diffusion Plant, Paper No. 57-NESC-46, 2nd Nuclear Engineering and Science Conference, Philadelphia, March 1957, Am. Soc. Mech. Eng., New York.
3. G. W. C. Tait, The Annular Impactor, Report No. CR-HP 577.
4. P. Drinker and T. Hatch, "Industrial Dust," Chap. V, McGraw-Hill Book Company, Inc., New York, 1954.

AIR CLEANING OPERATIONS AT THE ROCKY FLATS PLANT

Robert J. Walker
Dow Chemical Company (Rocky Flats)

Air filtration requirements at the Rocky Flats Plant have been typical for AEC operators, but thanks to a wealth of information and cooperation of many parties we have had no major problems in this field in recent years. At the Third Air Filtration Conference, the various ventilation systems in use at Rocky Flats Plant were described, so that information need not be repeated. At that time we had a total of approximately 1,150,000 cfm of air being handled. The systems consisted of standard ventilation components such as supply system, heating, air washing and air filtration, and exhaust system filtration.

Our expansion program involved about 600,000 cfm additional and all major components were designed to the same general criteria as used in the original plant. As a standard feature, we have always practiced the philosophy of containment in its highest economically feasible form. In addition to careful design in the process enclosures, this has included providing special prefiltration at hoods and providing separate "booster" exhaust systems for extremely contaminated operations. All air, however, eventually passes through a final filtration of AEC type Absolute filters.

Actually, the Absolute filters we have used have been very good for us, in both efficiency and cost. In general, our stacks have never run greater than 10 per cent of tolerance. We have also had the very minimum of maintenance problems with the Absolute filter banks. We cannot report any of the more drastic ailments such as filter media falling from the frames and filter media cracking around the dividers. In short, the filters have just existed with little or no work being done on our part. In a very few instances we have used a vacuum cleaner to remove large lint deposits from the face of Absolute filters, and in one of our buildings we have used a humidification process to extend the life of Absolute filters when loaded with a chemical salt. The life of these filters has in most cases exceeded our most optimistic original estimates; in fact, we have one building in which the filters have run continuously for slightly in excess of four years and still have less than 1 in. pressure drop.

Some of the items that have assisted us in getting such good service from these filters were designed into the systems, and others have been due to careful operation of the ventilation systems. In all of the major filter banks, enough filters were installed so that instead of the normal 1000 cfm going through a 24- by 24- by 12-in. filter we have only 400 cfm/filter. As a further help, all of the major ventilation systems are set up with three operating speeds that are roughly equivalent to one-third, two-thirds, and full fan capacity. We use the two-thirds quantity, medium speed, for all normal operating periods in the building. We use the one-third quantity, low speed, for all off-shift, nighttime and weekend operations. The high speed of full capacity of the fans is used only during emergencies in which the building has to be purged of its contaminants in the least possible time.

Provision for prefiltering at every possible operation has helped to extend the life of these filters, while more than ordinary filtration of supply air has also assisted in attaining this end. Thus, the average dirt load in the air going to the final filters is in the order of 0.03 grain per 1000 cu ft of air. The operators of these plants have greatly assisted the extension of filter life by keeping their fans on the lower speeds as much of the time as possible and by continuously maintaining the prefilters in their best possible condition. Further help has been the immediate addition of prefilters at any process that begins to show great amounts of dust and at any new processes that have been added.

In the process of operating these filters without change for periods up to four years, we have in some instances loaded a 24- by 24- by 12-in. filter with 13 lb of dirt. Our more normal loadings, however, have been in the order of 6 to 10 lb of dirt per filter. These loadings have been in our multiple-speed systems and at the derated filter air flows mentioned before. In addition, these loads have been obtained at rather nominal filter pressure-drop change points. As a general thing, we have to change our filters at 2.5 in. water gauge pressure drop across the filter because of the design limitations of our exhaust fans. With such loadings we feel we are getting the optimum in filtration efficiency, along with filter life at the least possible dollar expense. With a combination of original installed costs having run only $2/cfm and filter life such as this, any other type of filtration has to really be good to be considered.

Actually, then, our only complaint or worry with this type of filter is the danger of fire. We have always been very concerned over the danger of fire in our filter banks, and the recent reports of fires at other AEC installations have increased this concern. We have taken a number of steps to minimize this danger in the form of providing the best possible fire-detection system, by having the filter banks enclosed in rooms made of concrete, and by pretreating any air coming from a source of possible fire. From our early tests on filters, we had felt that normally when a single filter was ignited by a spark or some such means, with the air flow still going through the filter it would not tend to propagate to the rest of the filter bank. At present, however, we find that the dirt load in the filter itself is actually a very great contributor to the amount of combustible materials in a particular filter. As noted earlier, 13 lb of combustible dirt (lint, etc.) in a filter is approximately 50 per cent of the weight of the combustible dividers and media. Recent tests we have made on filters loaded in this way have shown a very definite tendency for fire to propagate from one filter to the next, so that if a fire started in one of these loaded filters much of the filter bank would burn before we could do much about it. Our problem in this field is further complicated in our new buildings because they are steel frame construction, and the structure itself could not stand the effect of a fire in a filter bank.

As a result of this, then, we have been very interested in the new, all-glass filters being developed by the major manufacturers of AEC type filters. We have also been actively following the work of the Hanford people in developing a specification for the most feasible fire-resistant filter. No matter how good the fire-resistant qualities are, however, it is our feeling the outstanding problem with these new filters is "what will the dirt loading be?" This sounds rather innocent at first but when you realize that we are attempting to get upwards of five years of life out of a filter, and have dirt loads approaching 10 lb, you realize that this is of great importance. Also, when you consider that we have approximately 3500 of the large 24- by 24- by 12-in. filters in use, an appreciable change in the life characteristics would greatly affect the operating costs for these filters. Our plant has therefore performed some very rough loading tests on the all-glass filters involving accelerated, artificial loadings. These tests so far have indicated that with our particular loadings we can expect filter life of only 10 per cent of our present filter life. Granted the method of test and measurement in such a limited time is somewhat questionable, it still indicates a trend of such a magnitude as to cause extreme concern on our part. Also consider that if we can get these new filters up to the loadings shown in our present ones, we then have 13 lb of combustible dirt in 25 lb of noncombustible filter. Can we then afford the added costs for the all-glass filters?

We are, therefore, quite eager to receive whatever data is available from the filter manufacturers who are to make presentations at this conference. We are also quite interested in the results of the tests that the Hanford group has performed on these filters. Therefore we are turning the tables, so to speak, in that we are posing a problem or asking questions of the conference rather than contributing any great and profound answers to your problems.

AEC BETTIS PLANT AIR CLEANING ACTIVITIES

P. R. Bolton and J. E. Ross
Bettis Plant

The air cleaning problems at the Bettis Plant, which is operated for the Atomic Energy Commission by Westinghouse Electric Corporation, consist principally of the removal of radioactive particulates and acid fumes and mists from process air. Wet and dry collectors are used for the various cleaning requirements encountered.

Approximately 30 wet collectors ranging in capacity from 2000 cfm to 8000 cfm are used where the exhaust air contains acid fumes and mists, or pyrophoric metals, or where it is at an elevated temperature. Typical uses are for acid pickling facilities, chemical laboratories, and uranium metal working operations such as melting, rolling, and machining. In other operations involving higher levels of radioactive contamination, the wet collector is used as a precleaner for a more efficient collector.

These wet collectors are either the American Air Filter Type N Roto-clone or the Schmieg Centri-merge.

For operations such as metal working, where the exhaust air does not contain highly corrosive materials, the body of the collector is constructed of carbon steel and the impellers are either type 304 or type 316 stainless steel. Corrosion is most severe on the impeller, hence the reason for using stainless steel. Corrosion of the carbon steel body progresses most rapidly at the water interface, i.e., where the metal is alternately covered with water and exposed to air. The average life of these units has been approximately 5 years although some have operated continuously for about 7 years before requiring replacement.

Units servicing acid pickling operations have a stainless steel body and impeller. Type 316 stainless steel is preferred, but type 304, being more readily available, is sometimes used. The corrosion resistance of these units has been satisfactory after 2 to 5 years of service with the exception of a few instances of weld corrosion presumably due to carbon precipitation in the weld.

Wet collectors exhausting natural uranium metal-working operations have given satisfactory performance. During the last eight months, daily stack samples from three such units averaged less than 10 alpha dis/min/m^3 (7 μg/m^3) and did not exceed 125 alpha dis/min/m^3, (83 μg/m^3). Daily samples from a fourth unit were slightly higher, averaging less than 20 alpha dis/min/m^3 (13 μg/m^3) with a maximum of approximately 400 alpha dis/min/m^3 (270 μg/m^3). This higher stack effluent concentration from the fourth unit has been attributed to the small particle size uranium dust and fume produced by the automatic cut-off wheel which is exhausted by this system.

As would be expected, the wet collectors are not effective for the removal of oxides of nitrogen from nitric acid pickling operations. However, they are satisfactory for removing acid mists and water soluble acid gases.

Daily inspections of the units are made to assure proper operation of the automatic liquid level control. The failure of electrical components of the liquid level control results in a low water level in the collector with loss of efficiency or water overflow from the collector which, in the case of radioactively contaminated liquids, places an unnecessary load on the liquid waste processing facilities. Caustic is added as required to control the acidity of the water and inhibit corrosion. Radioactively contaminated water is drained directly to the liquid waste processing facilities eliminating personnel exposures and area contamination such as could result from handling highly contaminated dry filters.

The highest levels of airborne radioactive contamination occur in the Hot Laboratory (high level radiation laboratory) where physical and chemical examinations are performed on multicurie radioactive samples. The exhaust air from the original cell block, which has been in use for 6 years, is cleaned by two-stage systems consisting of a wet collector of the type previously mentioned followed by a Westinghouse Precipitron as the final cleaner. The average daily concentration of radioactivity in the effluent from these systems over a period of several years has been 150 to 200 beta-gamma dis/min/m^3. Peak concentrations up to 50,000 beta-gamma dis/min/m^3 have been observed when certain operations were performed on particularly hot samples, notably, when these hot samples were sectioned by an underwater cut-off wheel. To accommodate the increased work load and the higher levels of radiation, a new cell block was put into service approximately a year ago. The dust collecting systems for these new shielded cells were designed to provide adequate cleaning of the more highly contaminated air which would be produced. They are three-stage systems consisting of a wet collector, an electrostatic precipitator, and a Mine Safety Appliances or Cambridge high-efficiency dry filter as the final cleaner. Average daily concentrations of radioactivity in the effluent from these systems have been less than 15 beta-gamma dis/min/m^3 and have not exceeded 2000 beta-gamma dis/min/m^3 in spite of the fact that those operations on hot samples which produce the most airborne contamination are performed in the new cells.

Maintenance problems on the electrostatic precipitators consist of replacing broken ionizing wires and defective power pack tubes and periodic cleaning of the collecting plates by the built-in water spray. The plates are sprayed with a water soluble adhesive which retains the collected material and aids in cleaning. The input voltage must be maintained at approximately 120 volts to obtain an ionizing voltage of 13,000 to 14,000 volts which is required for satisfactory cleaning.

The high efficiency filters in these systems have a life of approximately six months. They are changed when the pressure drop across them reaches approximately twice the initial value as indicated by a draft gauge.

High efficiency filters are also used in portable unit dust collectors where they are preceded by two layers of a fiber glass filter media (American Air Filter FG-50 filter media). These units are used for exhausting some uranium dioxide (UO_2) powder metallurgy operations and have given satisfactory performance. The life of the high efficiency filters has been greater than one year. The FG-50 prefilters are changed every 1 to 4 weeks depending upon dust loading conditions. Draft gauges on the units indicate the need for filter change.

Day dust collectors of the Hersey reverse-jet type, are used for the local exhaust ventilation of production scale powder metallurgy operations. The uranium dioxide dust loadings have been light requiring infrequent manual operation of the reverse jet. One smaller unit of this type is used as part of a pulverizing process for reducing the particle size of uranium dioxide for powder metallurgy operations. Air velocities through the wool felt bag are 12 to 15 ft/min for a total volume of 300 to 375 cfm. At dust loadings of 20 to 25 grains/cu ft, the pressure drop across the bag is about 4 in. Hg. The unit collects 60 to 80 lb/hr of uranium dioxide having a mean particle size approaching 1 μ diameter. This unit discharges into the larger collecting system along with the exhaust air from other processes. Tests on this unit have indicated that it has a collection efficiency in excess of 99 per cent for this particular application.

There have been no serious maintenance problems on these reverse-jet type bag collectors. Some difficulty was experienced from water collecting in one of these units which is located outdoors. Some of this water was from leakage through deteriorated gaskets at the joints and doors. Condensation could be a contributing factor in cold weather.

In general, the factors which were taken into consideration in designing these air cleaning systems were (1) the required collecting efficiency, (2) nature of the material to be collected, (3) maintenance problems, and (4) cost.

AIR CLEANING EXPERIENCE AT THE NAVAL REACTOR FACILITY

J. R. Horan
S1W Industrial Hygiene Group, Westinghouse Electric Corporation

1 INTRODUCTION

The S1W plant is a prototype nuclear power plant similar to the USS Nautilus which utilizes a pressurized water reactor as a heat source to supply steam to turbines, generating equipment, and similar components found in a conventional steam plant. This power plant has been operated successfully for over four years. During this time no employee has received any significant exposure as the result of inhalation of radioactive material. Since the feasibility of a submarine thermal reactor has been proven, the S1W plant has been transformed from a prototype operation to that of a test facility to supply important information for future water cooled reactors. The operations building contains a hot-cell and canal area, as well as chemistry laboratories for the testing, sampling, and analysis of highly radioactive materials.

Radioactive air contamination may result from primary coolant leakage in the power plant by a direct release to the atmosphere or by leakage into the steam system. The sampling or analyzing of radioactive material in the fuel handling area or chemistry laboratories is another source of air contamination.

2 CONTROL OF AIRBORNE RADIOACTIVE CONTAMINATION

2.1 Primary System Leakage

To remove air activity resulting from direct primary coolant leakage, we originally utilized a 600-cfm fan to exhaust air from the area into the following cleaning system before stack discharge: (1) dry cyclone, (2) air mat arrestor composed of cloth-cellulose fibers.

Two and a half years of operating experience demonstrated that this air cleaning equipment was unnecessary; therefore, discharge is now made directly to the stack without cleaning.

2.2 Secondary System Leakage

Primary heat exchangers of the type used at S1W, even though designed and built for high integrity, will develop primary to secondary leakage. With leak rates as low as 5 to 10 gal/hr a certain amount of contaminated steam will be released in the engine room area. This problem is of such a low order of magnitude that air cleaning equipment is not a feasible solution. Instead the problem is solved by dilution, using one or more of six available emergency exhaust fans, each fan having a capacity of 36,000 cfm.

We would like to find an inexpensive compact high efficiency air cleaner capable of removing contaminants from 300 cfm of radioactive steam.

2.3 Hot-Cell and Chemistry Laboratories Exhausts

Only low-level activity has been discharged to our air cleaning systems which consist of Roto-clone type N scrubbers, and two-stage electrostatic precipitators. Our main problem is to dry the air sufficiently by heaters to prevent electrical breakdown of the precipitator by high-moisture content of the air. Damage to the Roto-clone has been confined to heater damage caused by water minerals.

3 OPERATIONAL EXPERIENCE

3.1 Argon (Ar^{41}) Study

Less than 50 curies of Ar^{41} have been discharged to the atmosphere. This quantity resulted for a test specifically designed to evaluate the hazard from Ar^{41} in a confined space. To perform this test, several standard cubic feet of Ar^{40} were injected into the primary coolant and allowed to reach radioactive equilibrium. The Ar^{41} activity reached a maximum concentration of 2.6×10^{-7} µc/cc. Except for this test our total discharge of radioactive material to the atmosphere would be less than 1 curie. Fallout trays downwind of our project have never indicated the release of particulate radioactivity from our stacks.

3.2 Secondary System Leakage

The leakage of primary coolant indirectly to the atmosphere through the secondary system has not resulted in any hazard under normal operating conditions. With a primary to secondary heat exchanger leak of up to 100 gal/hr, levels of air contamination in the occupied areas increased to a maximum of 10^{-9} µc/cc of beta-gamma activity. Since the major activity of biological significance is Fe^{59}, this concentration is less than 0.06 per cent of the maximum permissible concentration based on National Bureau of Standards Handbook #52.

With fission products present in the primary coolant, air contamination of from 3×10^{-8} to 4×10^{-7} µc/cc have been experienced in the engine room area during special tests.

The unusual feature is that although iodine is the major fission product present in the coolant, no iodine has been detected in the air contamination by either filtration, scrubbing, or biological techniques. The predominant activity is 30 min Cs^{138}. Five coolers in the air-conditioning system proved very effective in removing a significant percentage of the air contamination through condensation.

3.3 Unusual Techniques

In confined areas, we have been successful in filtering low-level air contamination by the operation of one or more staplex air samplers with an all dust type filter (BM2133) recirculating the air at 30 cfm.

In unoccupied areas we have found that levels of contaminated air activity can be reduced by increasing the relative humidity to 100 per cent. This causes the radioactive particulates to rain out of the air, thus reducing the capacity of the atmosphere for radioactive materials.

AIR CLEANING ACTIVITIES AT GE-ANP IDAHO TEST STATION

R. M. Chatters
Technical Laboratories, General Electric Company, Idaho Falls

In view of the increasing interest in fallout and other potential sources of radiation damage to human populations, the General Electric Company has accelerated its existing investigational program dealing with radiation hazards.

The General Electric Company's situation at its Idaho Falls Aircraft Nuclear Propulsion Test Station is a rather paradoxical one. The very meteorological and physiographic conditions which make the Upper Snake River Plain so desirable as a reactor site often militate against the operation of the reactors due to their effects upon the dispersal of stack effluents.

For the benefit of those who may not be familiar with the Idaho Test Station site, I will take a few moments to describe the area. The installation is part of the National Reactor Testing Station which includes Phillips Materials Testing Reactor, Engineering Test Reactor, Chemical Processing Plant, Argonne's Experimental Breeder Reactor, and the Naval Reactor Facility. It now occupies about 460,000 acres of the vast Upper Snake River Plain west of the city of Idaho Falls, the closest heavily populated town. The plain which is about 60 miles wide and more than twice as long is surrounded by mountains, some of which on the west are as high as 11,000 feet; and on the northeast the Grand Tetons reach altitudes in excess of 13,000 feet. It becomes readily apparent that with the wide disparity in physical conditions between the warm, arid, and relatively flat desert floor to the snow covered peaks of the Tetons, many variable weather conditions can and do occur at the reactor site.

Because of the location of the Idaho Test Station of the General Electric Company relative to other reactor sites on the Snake River Plain, the operation of the reactors is limited to those times when the wind currents are from the southwest—which, fortunately, is the direction of prevailing winds.

Among the vagaries of nature which affect the operation of the General Electric facility are the occasional sudden changes in wind direction caused by the movement of winds down one of the nearby mountain passes. Winds which may be blowing from the southwest over the effluent stack at the Initial Engine Test facility, permitting reactor operation, will suddenly shift to come from the northwest, thus requiring cessation of reactor operations until southwesterly winds are again re-established. This may require several hours. These same northerly winds continue down the valley and encounter southerly winds blowing from the Materials Reactor Testing site 20 miles away. The nature of the shearing of the two directional air masses is not yet fully known.

From the foregoing, it is obvious that a solution for the problem of air pollution becomes more complex as reactors increase in number on the Snake River Plain, and that a better understanding of the paths taken by stack effluents and their contained constituents warrant detailed study.

In order that the General Electric Company can cope with this situation, tests and observations are now under way to acquire a more detailed knowledge of the movements of our stack effluents and of their composition.

Recently, the U. S. Weather Bureau offices at Idaho Falls proposed to investigate the shearing of the simultaneous north-south winds along the floor of the plain by means of smoke plumes. The U. S. Air Force was to provide aerial photographic assistance and the G.E. Idaho Test Station was to send up a smoke plume from a 167-ft stack for comparison with ground level activity. Perversely enough, the looked-for phenomenon did not occur before warmer weather set in; hence, the tests have been postponed until fall when weather conditions will more frequently again be favorable for the propogation of the two-way winds over the test area.

An independent series of smoke plume studies have been started by us in Idaho and are intended to provide information on the movement of smoke from the 150-ft stack at the Initial Engine Test facility. Of special interest is the determination of the effective stack height because of its value in diffusion of the effluents.

As the General Electric Company develops its study of an air-cooled direct cycle reactor, it is our intent to continue the smoke plume investigations under varied weather conditions both summer and winter until we feel that significant data have been obtained.

The smoke plumes which are being studied have been produced by oil and water smoke generators, smoke bombs, and titanium tetrachloride and ammonia. Examination of the plumes is being aided by the use of infrared detectors such as the sniper-scope and recorded permanently on movie film, and by black and white plus infrared photography. The photographs will provide us with information on the structure of the plumes as well as their paths of movement.

To provide a clearer concept of the amount of radioactive effluent which might be released from the Aircraft Nuclear Propulsion area, a program for the development of filtering devices has been in operation for some time past.

These investigations include the testing of filtering systems and adsorbents using in-pile loops at the Phillips Petroleum Company's Materials Testing Reactor site, out-of-pile test loops within effluent ducts at the Initial Engine Test pad, withdrawing and monitoring of air from the IET stack, and the employment of electrostatic precipitators.

A testing program has been initiated at the Materials Testing Laboratory which will investigate in detail the feasibility of using a multiphase filtering system in which several adsorbents specific for individual components in the stack effluents will be examined. Likewise, the program calls for testing the comparative efficiencies of various solid adsorbents, some of which will be conventional types and others which will no doubt be classed as exotic, if not bizarre.

We have been fortunate in having the assistance of the Harvard Air Cleaning Laboratory personnel and a number of other persons on this investigation, but will welcome further help from others in order that we may reach a satisfactory and speedy solution to stack effluent dispersal problem at the GE-ANP Idaho Test Station.

AIR CLEANING OPERATIONS AT KAPL

W. H. Truran
Knolls Atomic Power Laboratory

1 INTRODUCTION

Air cleaning operations at the Knolls Atomic Power Laboratory continue to receive deserved attention after seven years of operation to maintain their optimum effectiveness in promoting employee and public health. Through accumulated operating experience, and revisions in laboratory functions and facilities, air cleaning maintenance has been programmed, air cleaning services have been reduced, and new air cleaning facilities are improved.

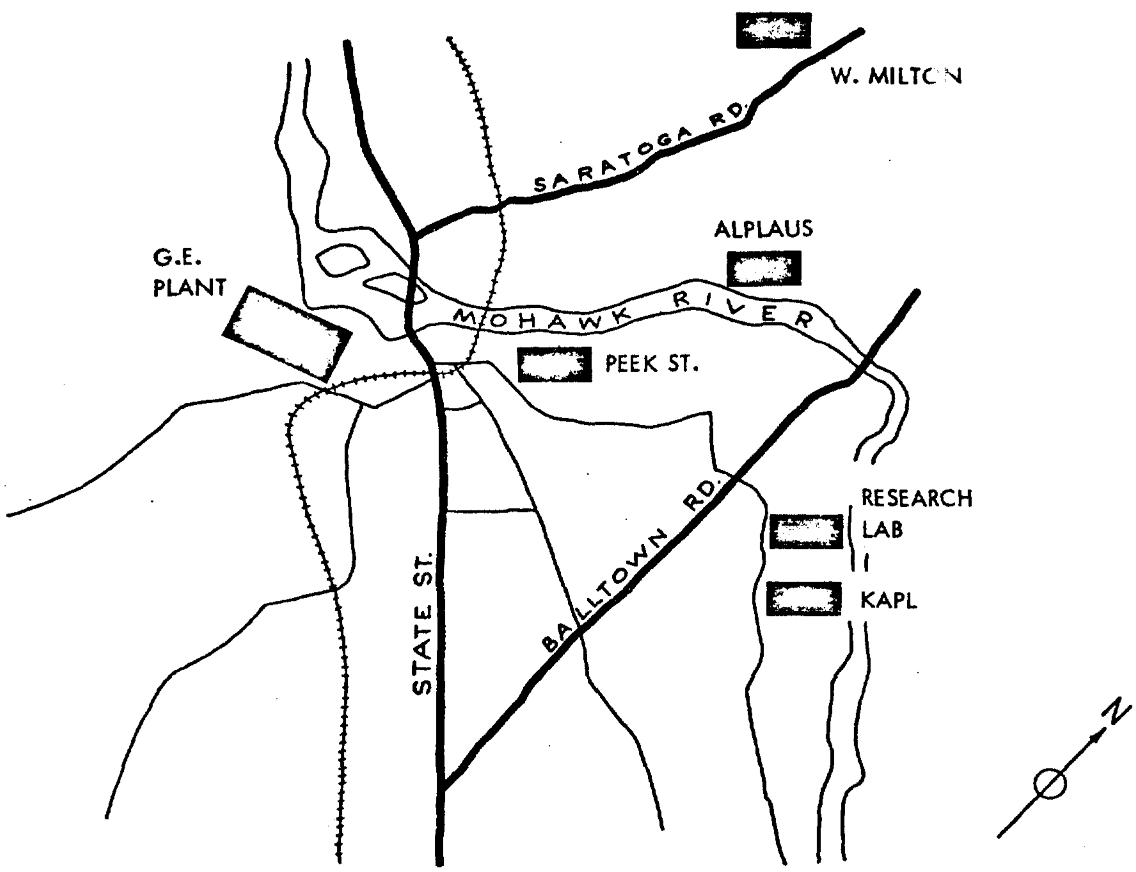


Fig. 1—Location of Knolls and West Milton KAPL sites.

2 THE LABORATORY

The Knolls Atomic Power Laboratory is engaged in the development of naval propulsion reactors. Its facilities occupy two sites. The Knolls Site is approximately five miles east of the center of Schenectady. The West Milton Site is approximately eighteen miles to the north. Their locations are shown in Fig. 1 together with the locations of the neighboring General Electric Research Laboratory and the General Electric Main Plant in Schenectady, New York.

The Knolls Site facilities (Fig. 2) requiring air cleaning services include physics, chemistry, and metallurgy laboratories; shielded cells for the examination of irradiated reactor components; a fuel element and reactor fabrication area; two critical assembly buildings; liquid and solid radioactive waste processing areas; and a laundry for laboratory clothing.

The West Milton Site (Fig. 3) facilities include nuclear power plant buildings and fuel service buildings. Investigations with the prototype for the nuclear power plant installed in the submarine, Seawolf, have been completed. The prototype for an advanced nuclear power plant to power the submarine, Triton, is under construction.

The personnel compliment of the Laboratory is approximately two thousand. Eighteen hundred are employed at the Knolls Site.

3 AIR CLEANING SYSTEMS

Air cleaning systems are either single-pass or partially recirculating systems. Ventilation air is not recirculated when ventilation is relied upon to control personnel exposure to airborne contaminants during established operations. Such systems service chemical laboratory hoods, glove boxes, shielded cells, and a special materials machine shop where uranium is machined. The ventilation air is partially recirculated in areas where air cleaning would be required only as a result of an unusual incident such as the failure of glove box ventilation or in a critical assembly area where personnel are not involved during operations.

Whether single-pass or partially recirculating, if the expected contaminant is significant amounts of plutonium, enriched uranium, or fission products, cleaning of exhaust air is performed by a Cambridge Absolute Filter, preceded by a Dust Stop Fiberglas Filter (Fig. 4). If the possible contaminant is limited to natural uranium or beryllium, an American Air Mat Filter is the air cleaner. It is preceded by a cyclone separator for machining operations. Exhaust systems for nuclear power plant buildings are complicated with condensers, compressers, and isolation valves to satisfy reactor safeguards requirements.

Where absolute filtration of single-pass exhaust air is provided, supply air is precleaned with self-cleaning oil filters and electrostatic precipitators. This helps to minimize the dust loading of exhaust filters. Make-up air for partially recirculating systems is filtered with Dust Stop filters. Shop supply air is not precleaned.

4 OPERATING EXPERIENCE

Experience has indicated the need for a monthly preventative maintenance inspection of all air moving equipment. The condition of motor and fan bearings, belts, and fan blades are determined. Maintenance is required on the average of once a year. Substantial replacement is anticipated after 5 to 10 years of continuous operation. Air cleaning equipment is also inspected at least once each month. Special cases may be inspected as often as once each week.

In supply air systems, self-cleaning oil filters are steam cleaned every six months. Electrostatic precipitator wires and insulators are scheduled for cleaning every three months, although cleaning is presently required every two months because of construction in the neighborhood. The frequency of changing Dust Stop filters in make-up air systems has jumped from every 2 months to 2 weeks because of construction.

In single-pass systems requiring absolute filtration of exhaust air, Dust Stop prefilters may require changing in periods ranging from three months to a year. In partially recirculating systems with Absolute filters, the Dust Stop filters generally last a year.

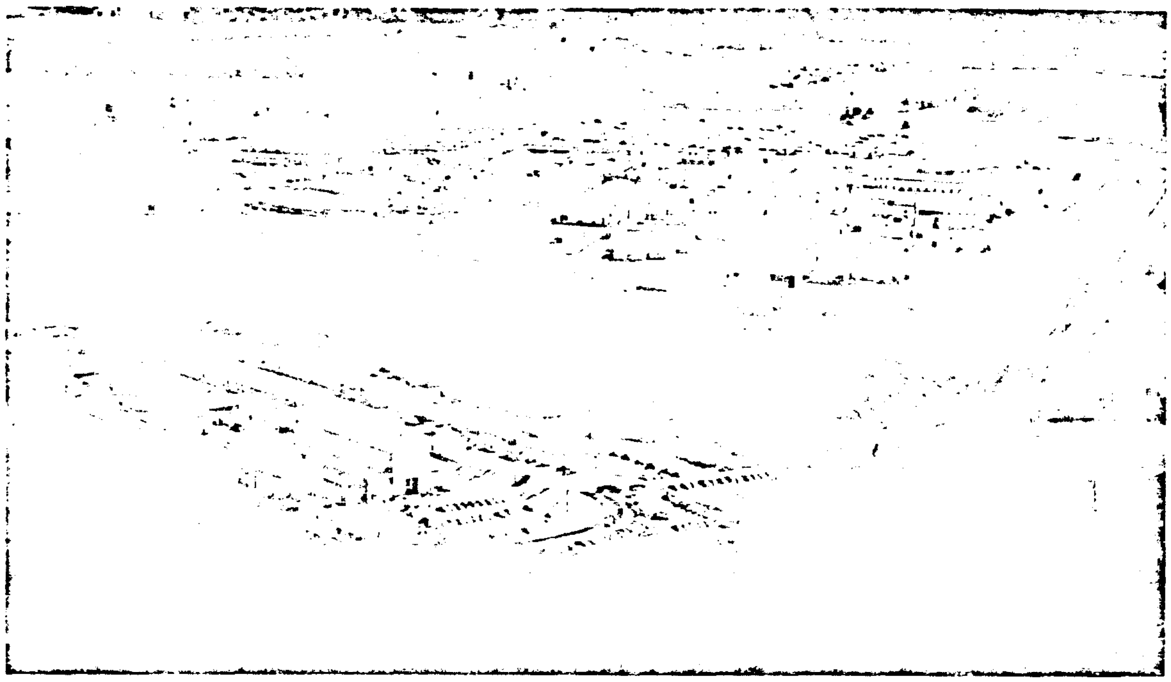


Fig. 2—Knolls site.

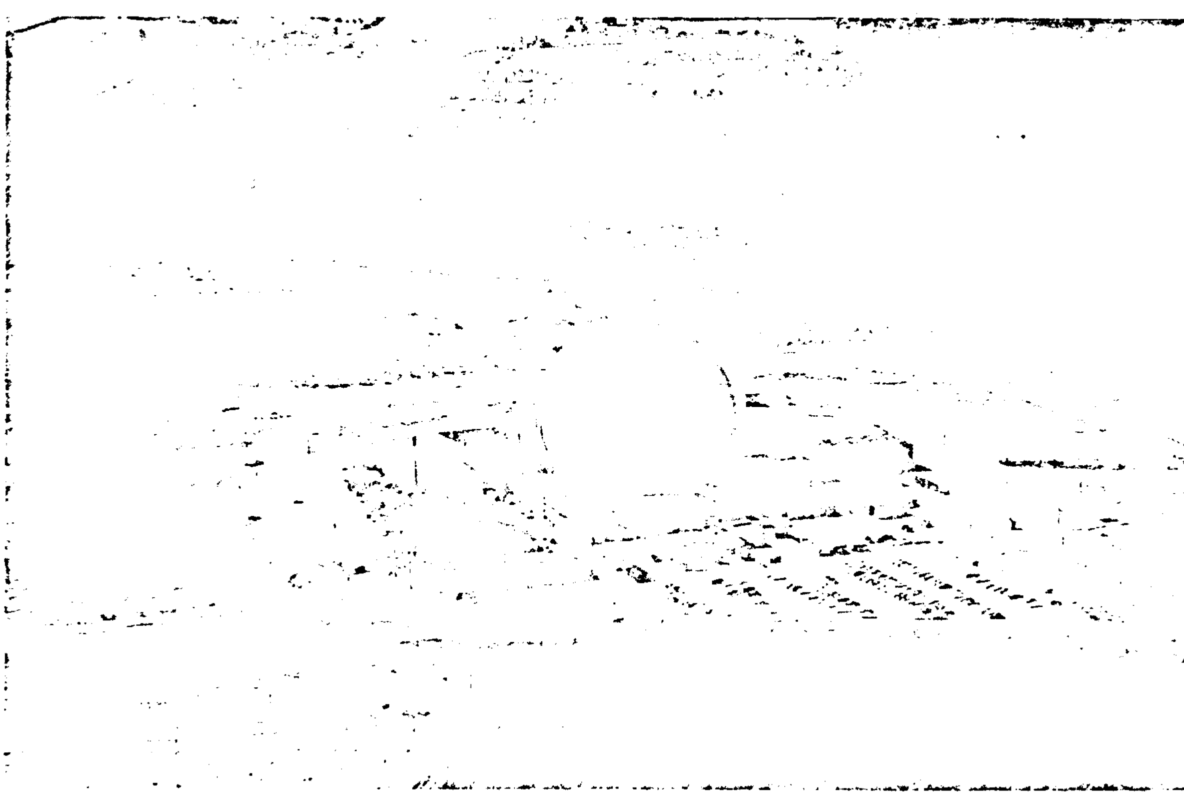


Fig. 3—West Milton site.

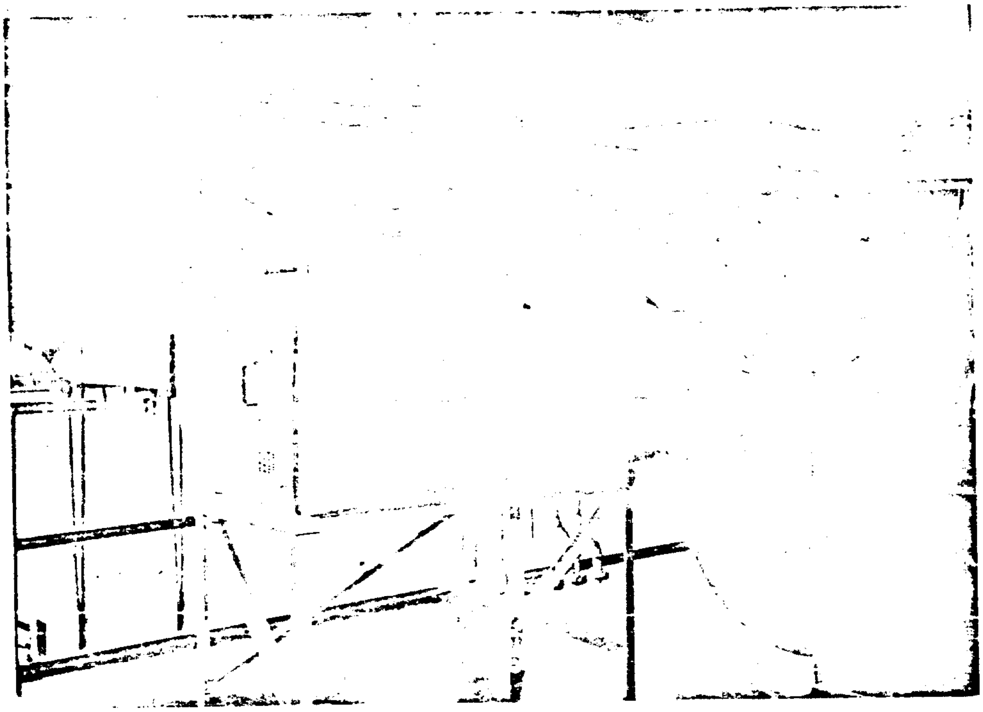


Fig. 4—Filtering system.

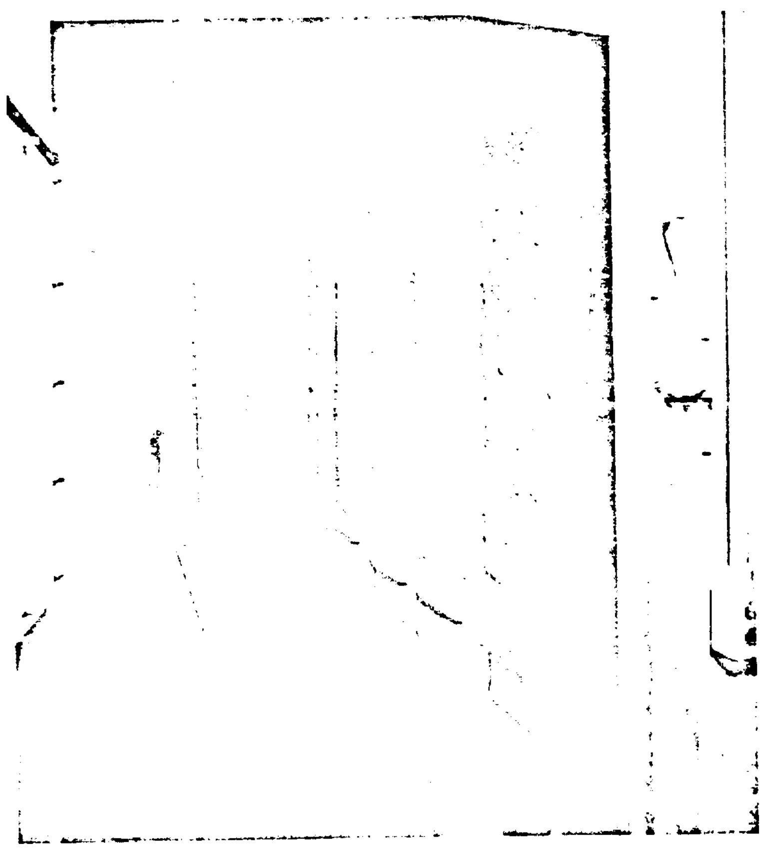


Fig. 5—System to reduce precipitator load.

Dust Stop filter changes are indicated by reduced exhaust velocity and increased pressure drop across the filter. Absolute filter changes are required by build-up in levels of radiation rather than dust loading. Some Absolute filters have been in use seven years.

The cyclone separator in the special materials machine shop is cleaned in periods of from 1 to 3 months, depending on the level of work load in the shop.

The air cleaning equipment for shop exhaust air originally included an electrostatic precipitator which processed air exhausted directly from machine tools following its passage through a cyclone separator. Due to the dust load created by machining operations, the precipitator required cleaning and maintenance once a month to keep ahead of short circuited and broken collecting wires. In order not to interfere with shop operations, maintenance was performed on off shifts. To ensure proper operation the following day, the man-hours required were so costly and inconvenient as to suggest the need for a better way. An American Air Mat Filter was installed preceding the electrostatic precipitator to reduce the precipitator load (Fig. 5). Investigation of contamination concentrations in exhaust air following the glass mat filtering, with the precipitator inoperative, indicated no need for the electrostatic precipitator with existing shop operations. This has continued to be the case for three years and no future need for the precipitator is anticipated. The mat filter is inspected visually and replaced every 2 weeks to 2 months, depending on shop workload.

A ventilation system being constructed for a critical assembly at the Knolls Atomic Power Laboratory is a partially recirculating, conditioned, and filtered system for the critical assembly area, separate from the control room and all adjacent areas. The filters are the series of rough and Absolute filters.

In the original systems provided for such operations at the Laboratory, experience and economy suggested a common air-conditioning unit in two parallel ventilation systems, one for the critical assembly area and one for the adjacent fuel storage, sub-component assembly, and reactor control room area. The two parallel systems were provided with dampers to shut down one in the event that toxic contaminants were picked up in the other but no filters were included. No problem arose in five years of operations. Revisions in last year's operations resulted in two minor incidents, one of which could be considered accidental, the other a part of revised operating conditions which were to continue. In the accidental case, radioactivity in the form of surface contamination was spread throughout the ventilation duct work of both the critical assembly rooms and the adjacent areas before the ventilation system was shut down. In the latter case, a nuisance level of short-lived radioactivity was detected by air samples in personnel-occupied areas which could only partially be corrected by dampering or shutting down all air circulating equipment.

Although in neither case did personnel exposure give cause for concern, the conditions inconvenienced reactor operations and pointed to a condition which could be intolerable in the event of a supercritical reactor incident. For these reasons in recent designs the ventilation system for a critical assembly area is completely isolated from all adjacent operating areas. The exhaust air is filtered to promptly reduce concentrations of particulate material. The air is recirculated to permit short-lived gaseous fission products to decay and be absorbed on filters and filterable material. The system is convertible to a single-pass system.

The program to evaluate the radioactivity content of atmospheres in operating areas, in exhaust ventilation, and in the environment of KAPL sites continues to demonstrate adequate cleaning of exhaust air. Occasional situations call for the wearing of respiratory protective devices temporarily in operating areas, such as an emergency spill of radioactive liquid, planned maintenance of radioactive waste processing equipment, or modifications within shielded cells. In only two cases are respiratory protective devices a part of routine operating conditions: unventilated critical assembly areas are entered following assembly operations and prior to the decay of short-lived airborne contaminants; the exhaust ventilation applied to baling of compressible radioactive waste, though generally adequate, is not sufficient to eliminate the need of respiratory protective devices in all cases. These operations are of short duration and respiratory protection requirements have not been objectionable. No significant exposure of Laboratory personnel has resulted from the inhalation of airborne contaminants as indicated by air sample and biosample analyses. Exhaust ventilation and environmental monitors continue to indicate no influence on levels of environmental contamination attributable to Laboratory exhaust ventilation.

REFERENCES

1. L. J. Cherubin and J. J. Fitzgerald, KAPL Air Cleaning Program, KAPL-1014, Jan. 4, 1954.
2. E. S. Collins, Mechanical Specialist, Operations and Maintenance, Plant Operations Section, Knolls Atomic Power Laboratory.
3. W. H. Truran, Knolls Atomic Power Laboratory Air Cleaning Program, (Part 1) Fourth Atomic Energy Commission Conference Held at Argonne National Laboratory, November 1955, TID-7513, USAEC Technical Information Service, Oak Ridge.

AIR CLEANING ACTIVITIES AT ATOMICS INTERNATIONAL

A. A. Jarrett
Atomics International

The prevailing practices at Atomics International, a Division of North American Aviation, Inc., to prevent environmental contamination by radioactive materials have been to use controlled air flow patterns in the laboratory from colder to hotter areas, to use prefilters followed by high efficient filters before discharge, and to collect radioactive gases in tanks prior to controlled discharge to the environment after decay.

In the main research laboratories at Canoga Park, a plenum containing twenty 20- by 20-in. Dust-Stop prefilters 4 in. thick and an array of 20 high efficiency final filters cleans approximately 15,000 cfm of air from laboratory operations. Influent air is cleaned electrostatically. Prefilters have been changed semiannually and final filters once a year when the combined pressure drop exceeds 2.5 in. water. Filter changes are determined by lowered air flow velocity across the face of laboratory hoods resulting from decreased efficiency of the blower rather than pressure drop across the filters. Under these circumstances the flow is approximately 10^8 ft of air between yearly changes of the final filtering media.

More emphasis must be placed on the instrumentation needed for evaluating the performance of installed air cleaning systems and the need for practical methods of control of radioactive gaseous effluents.

AIR CLEANING ACTIVITIES AND ASSOCIATED STUDIES AT GOODYEAR ATOMIC CORPORATION

Ben Kalmon
Goodycar Atomic Corporation

1 AIR CLEANING

Air cleaning at Goodyear Atomic Corporation may be grouped into two classifications: (1) air being discharged from various processes into the atmosphere outside the building to prevent possible air pollution within the buildings, and (2) local exhaust ventilation around various operations to keep the air contaminants in the worker's breathing zone well below the maximum allowable concentration (MAC) of chemical contaminants or below the maximum permissible limit (MPL) of radioactive uranium compounds.

The principal airborne contaminants resulting from plant operations are uranium and fluorine in various chemical forms, including fluorine itself, hydrogen fluoride, and chlorine trifluoride. Recently, other metals, fumes, and gaseous materials have been encountered among which are mercury (as used in the instrument maintenance facilities), nickel, iron oxide, welding fumes, and cadmium.

In locations where process gas is vented to the atmosphere, special chemical and/or mechanical traps are installed to collect the uranium before the process gas is vented. Although special traps are used for the elimination of hydrogen fluoride, we presently have no suitable method for the elimination of fluorine and, therefore, we have a potential fluorine air pollution problem. As a result, extensive background studies are made to determine whether fluorine air pollution is occurring.

Approximately one year ago, considerable difficulty was experienced with condenser corrosion. To check the corrosion, the method of water treatment was changed. This method of water treatment required the use of hexavalent chromates and sulfur dioxide; as a consequence, mists containing chromates issued from our cooling towers and it became necessary to conduct extensive surveys for chromate as well as sulfur dioxide. The surveys revealed no appreciable concentrations of either contaminant.

In regard to "air cleaning" the workers' breathing zone, the following is a brief summary:

1. *Welding Fumes.* Welding operations are of extreme importance at a gaseous diffusion plant. Wherever welding is performed in fixed locations, local exhaust ventilation is supplied to control the fume hazard. However, there are times when welding has to be done where local exhaust ventilation is not available. At these times, respiratory protection is worn by the welder.

2. *Metal Dusts.* Certain operations, particularly buffing and grinding, are dust producers and sometimes require high velocity local exhaust ventilation. Iron oxide fumes present a new problem during extensive burning operations. The concentrations have been as high as 26.6 mg/m^3 (MAC, 15). A local exhaust system has been approved for installation for three exhaust locations.

3. *Degreasers.* Organic solvent degreasers very often require a lateral slot exhaust type ventilation to permit the vapors from escaping into the surrounding area. We have five trichloroethylene and one Freon vapor phase degreasers. All degreasers have adequate exhaust ventilation, the amount depending upon the size and type of degreaser.

4. *Mercury.* The area where mercury is reclaimed is also provided with good local exhaust ventilation to prevent the accumulation of mercury vapors in the breathing zone of the workers.

In these operations the exhaust air is vented directly from the roof or the side of the building involved with no filtration or scrubbing. The amount of material involved in each case is relatively small from an air pollution viewpoint so that direct discharge with the associated dilution is considered adequate.

To determine whether local exhaust ventilation is needed or is adequate, routine air samples are taken around various processes for such metals as zinc, uranium, cadmium, nickel, and mercury and gases as trichloroethylene, nitrogen dioxide, fluorine, hydrogen fluoride, and carbon monoxide.

An evaluation is being made of an inert gas welding operation for the necessity of local exhaust ventilation. Preliminary results indicate that additional ventilation will be required.

1.1 Special Problems

One area of particular concern has been in a sampling facility where samples of product are withdrawn for analysis. Because of the level of U^{235} assay, the alpha activity is high. In this type of operation, uranium hexafluoride is withdrawn from cylinders by heating and valve systems are used extensively. Due to repeated usage, the valves eventually develop minute leaks.

The average airborne activity may be in excess of the MPL in as many as 20 per cent of the routine samples collected. As a result of this activity additional hoods and filter systems are being installed.

This system will be of an enclosed hood type over two adjacent work areas with separate exhaust fan and filtration system. It has been observed that considerable airborne concentration of hydrolyzed uranium hexafluoride can be traced to loose floor contamination due to the mechanical action of employees walking around. A stainless steel floor is being installed in this area so that the area can be more efficiently decontaminated as compared to concrete floors. A few cases have been reported of hydrogen fluoride skin burns due to the reaction of the process gas with perspiration.

2 EXTERNAL ATMOSPHERIC CONTAMINANTS

The major atmospheric contaminants as previously mentioned are fluorides. Since the threshold of odor is low, any fluorides vented to the atmosphere are readily detected. Considerable time and effort are directed to an extensive routine air sampling program. Air samples for fluorides and uranium are collected on a monthly basis within a radius of approximately five miles. The maximum average airborne fluoride concentration is 0.03 ppm. It has been observed that the average vegetation uptake is in the range of 25 to 30 ppm, up to five miles. It has also been noted that no definite correlation exists with wind direction or distance. The maximum values are generally found within a distance of 2 to 3 miles.

Plans are being made to recover the fluorides by returning the vent gases to a new feed manufacturing facility using a return line approximately one mile long. The recovery of the fluorides will serve two obviously desirable purposes: (1) the economic value of the recovered fluorides, and (2) the reduced airborne concentration.

2.1 Special On-Site Clover Damage Study

Early in November 1955, an area of clover on plant site became discolored and was found to be severely injured. Samples were collected to determine the fluoride uptake. This area was to the northeast of the top vent and parallel to the prevailing wind direction. Ten samples were collected at various distances up to an estimated 3000 ft from the vent. Of the ten samples, four collected from 825 to 1500 ft were severely injured. In the range from 1650 to 2000 ft, three specimens were moderately injured. At distances from 2300 to 2800 ft the clover exhibited slight injury. Samples taken at distances of 3000 ft or more indicated no injury.

The laboratory results were correlated with the degree of injury and the following general conclusions were made: 100 ppm, no injury; 110 to 175 ppm, slight injury; 225 to 350 ppm, moderate injury; and in excess of 490 ppm, severe injury.

In the spring of 1956, the newly grown crop of clover again exhibited the same pattern and a plot of the uptake vs distance indicated the same slope for both sets of data.

A plot was made on log-log paper of fluoride uptake vs distance from the top vent. The results indicated that uptake followed an inverse square relationship for the range covered. The points on the curve fall well within the limits of experimental error.

2.2 Extended Background Survey

In late summer of 1956, an extensive background survey was conducted to establish the normal background levels of fluorides in the Scioto River, in various species of vegetation, soil, and milk, and fluorides and sulfur dioxide in the atmosphere. This survey was desirable to determine background data in evaluating routine monthly surveys and to provide a means of detecting any build-up of contaminants. Samples of grass, clover, corn, pine needles, and soil were collected and analyzed for fluorides at 32 selected locations. A sample of each available species was collected at each location and isolated from the other species. The area covered was approximately 1385 sq miles with locations as far as 22 miles from the center of the plant activity. The locations were selected on a rectangular grid pattern and on the basis of prevailing wind and accessibility.

Continuous 24-hr air samples were collected to determine the airborne conconcentrations of fluorides and sulfur dioxide. The samples were collected simultaneously at locations from 7 to 25 miles from the plant in north, east, and south direction.

Eleven milk samples were collected and analyzed to determine the fluoride content of milk from dairy cows in the vicinity of the plant as compared to that from cows remote to the plant. Samples were taken as far as 34 miles from the plant. Four samples were collected from 2 to 6.7 miles surrounding the plant.

To evaluate the contamination in the Scioto River that could be attributed to plant operations, the river was surveyed from Chillicothe (25 miles north) to Portsmouth (22 miles south) at 12 locations. The time of collection at each sample point was scheduled to coincide with the river flow rate. This was done by following a float carried downstream by the river current. Samples were collected in each instance just upstream from the confluence of each major tributary. Chemical and radiological analyses were made for uranium, fluorides, hexavalent and total chromates, pH, and beta activity.

There were no indications that the contaminant concentrations in the milk, air, or Scioto River samples were different at points in the vicinity of the plant or at remote locations.

The average fluoride uptake in vegetation among the various species was statistically different at the 95 per cent confidence level. In general, the clover uptake was the highest; hence, future surveys can be limited to clover as this was the most sensitive indicator. The average uptake in pine needles was the lowest of the species analyzed.

The effect of prevailing winds is not evident. Based on the prevailing wind direction, it was expected that the northeast quadrant averages would be the highest. The highest values were found in the southeast and northwest quadrants.

The statistical analyses by quadrants and distance indicated no clear pattern and very little, if any, correlation.

The concentrations found in soil were erratic and random; for example, the highest value (350 ppm) and the lowest value (79 ppm) were found in approximately the same direction and the highest value was found at twice the distance from the plant site as the lowest value.

Because of the lack of correlation and erratic results, more surveying is being done. So far, it appears unlikely that plant operations have affected the vegetation fluoride concentration background at distances greater than five miles, and that the fluoride concentrations are random in nature. Although there is some evidence of increased fluoride uptake within a five-mile radius of the exhaust stack, no indication of off-site vegetation damage has been detected. Based on the clover study previously discussed, it is apparent that vegetation beyond five miles would be unaffected by plant operations.

DEVELOPMENTS IN HIGH EFFICIENCY AIR FILTRATION

Paul M. Engle
Cambridge Filter Corp.

I would like to extend two invitations. First, we have on display a considerable number of new and special Absolute and Aerosolve Filters. We will be at the hotel this evening and will be very happy to discuss filters of any type and questions involving their application with you there or even here immediately after this meeting. Bill Baldwin who is the engineer in charge of our manufacturing department is here and since development is my field, I believe we are well equipped to handle questions of every nature. I spent eight years on AEC contract work with Monsanto and feel that I understand a lot of your special problems.

The second invitation is to visit our plant in Syracuse. This invitation is always open. We'll be very happy to have you tour our manufacturing operations and discuss your particular problems. A number of our good customers have done this and we always find it mutually helpful.

I will touch briefly on some of our development programs and hope to continue the discussion with you at our display. One of our more recent developments is an adhesiveless Absolute filter. These filters are very useful where organic materials are taboo such as in contact with perchloric acid. This approach is also recommended when a fireproof filter is required.

Absolute filters with plastic separators have been developed for certain applications where corrosion resistance is important.

Cylindrical filters have been constructed for several customers. These are particularly useful where the filters are to be installed in pressure containers. As you might imagine the production problems which were solved to make this item possible were considerable. We are proud of the improvements in manufacturing made over the years which enable us to sell filters at less than their price six years ago, in spite of constantly increasing material and labor costs. I doubt if there are many articles you buy which can equal this saving. The price reductions now taking place in the glass media Absolute filters are particularly noteworthy. These will make fire-resistant filters more economical.

Since fire resistance is an important point of discussion at this seminar, let me mention our conclusions on this subject. We have found that as long as the media and separators are fireproof it is extremely difficult, if not impossible, to start a fire in the frames and adhesive even with a blow torch. The filters on which these tests were run employed ordinary plywood frames and rubber-based adhesive. We feel that further modification is probably unnecessary and may lead to a sacrifice of other properties, but, if it is required, we'll be glad to make it.

In general, I am sure you gentlemen understand the design and manufacture of standard Absolute filters, but there might be some details regarding their construction which would be interesting.

1. There are 200 or more square feet of filtering area in each 24- by 24- by $11\frac{1}{2}$-in. filter. This means that at rated capacity the approaching air is spread out and slowed down by a factor of 50 before being filtered. This explains to a large extent how the filters can be so extremely efficient and still have reasonable pressure drop. This tremendous filtering area also explains why the life and dirt-holding capacity of the filters are so great.

2. Another important factor in the manufacture of Absolute filters is that there are no "seconds." After a filter is assembled if it does not meet the DOP smoke test, there is nothing that can be done. It is then scrapped. Fortunately over the last seven years we've had the same personnel building these filters and they've developed enough skill that we now lose very few filters.

3. The third point I want to emphasize is that in spite of increasing volume we've been able to keep our manufacturing flexible enough to accommodate special filters of almost any size or type conceivable. We have been supplying increasing numbers of Absolute and other high efficiency filters to industry for a number of years. These customers have a wide range of special problems such as corrosion, fire resistance, and steam sterilization. We have built

at least 20 different types of Absolute filters in the last year alone, not to mention the number of standard and special sizes. This experience is available in assisting you to solve your special problems.

Before closing I would like to mention briefly our other important development in the high efficiency air filtration field—our Aerosolve Filters. These filters are a two-piece unit consisting of replaceable cartridge and a special metal permanent support frame. They do not approach Absolute filters in efficiency, but rather were developed primarily for commercial applications covering a range of efficiencies up to and slightly above that provided by electrostatic precipitators. Aerosolve filters are frequently used as prefilters to Absolute filters.

Because of the lower efficiency, we certainly do not recommend that you replace your Absolute filters on highly radioactive exhaust systems with Aerosolves. We do feel, however, that there are less critical air cleaning problems at many of your plants where the efficiency and positive strainer-type action of the Aerosolve filters would be very valuable.

One good example is on supply systems where the exhaust will eventually become contaminated. It is certainly more economical and less trouble to remove ordinary atmospheric dust with efficient filters on the supply system, than to have this dust add to the load on the contaminated exhaust filters.

Aerosolve filters are also useful on certain exhaust applications. In fact, one of the AEC sites purchased a considerable number of our Aerosolve 95's soon after they were introduced over two years ago. On the basis of results obtained with these original installations, they are now installing these filters in additional systems.

Aerosolve 95 filters have a considerably lower pressure drop than Absolute filters and the replacement cartridges are less expensive. They are listed by Underwriters Laboratories.
In closing, let me again invite you to visit us.

DEVELOPMENTS IN THE MANUFACTURE OF ABSOLUTE FILTERS

A. R. Allan, Jr.
Flanders Mill, Inc.

We are not yet able to offer for sale a filter made without cement such as our competitor claims to offer. However, we are sure that the subsequent savings in material in such a filter will be passed on to the consumer by our competitor.

Our latest development is an all ceramic filter that can be used, without injury to the filter, in temperatures up to 2300°F. I would like to pass this around while I continue my talk. The ceramic fibers disintegrate at 3200°F, and the filter may be used for a short duration of perhaps one hour at 3000°F. As the filter is of a homogeneous construction, it will withstand heat shock very well. Our units have been DOP tested and sent to the Buffalo Forge Company for heat testing. The filters were taken from room temperature and placed in an oven heated to 1500°F; they remained in the oven for approximately one hour and were withdrawn immediately to room temperature. The filters, after having been returned to us, were again DOP tested and no change in smoke penetration was noted. If anyone can tell us how we can DOP test these filters at a temperature of 2300°F, we would greatly appreciate it.

Unfortunately, the efficiency of the filter medium is not as good as that obtained with CWS or fiber glass media. It is 99.50 per cent at the rated capacity of the filters. However, the resistance is only about 60 per cent of the other filter media. The cause of the lesser efficiency is not inherent in the ceramic filters, but is due to the diameter of the ceramic fibers used in the media. No ceramic fiber exists, as yet, of sufficiently small diameter to increase the efficiency. Possibly, a greater demand for this small diameter fiber will result in its manufacture. These ceramic filters are made in all the standard sizes with the exception of the 24- by

30- by $11\frac{1}{2}$-in. size. There are two different frame designs, one having a flange cast into the frame on one side, and the other having a uniform frame $\frac{1}{2}$ in. thick all around the filter medium. The filter having the flange has a greater resistance at the same flow than the one without the flange. This is due to the space lost in providing a flange with the same over-all dimensions as the body of the other frame type.

The most recent development in glass media is a sheet 20 mils thick. We believe this to be quite important to filter users, as its efficiency is greater than the CWS and its resistance less by 10 per cent. We are willing to guarantee a smoke penetration of no more than 0.03 per cent and a resistance of not more than 0.9 in. wg at rated flows for filters made with this medium.

It is not affected by moisture and its fire resistant qualities are naturally superior to that of the CWS. We believe the strength of this new medium to be superior to that of the CWS. Static pressure tests were made across one of these units which was a reject. The smoke penetration of the unit was 0.07 per cent. Pressure was built up to 13 in. wg, and the filter was given a DOP test. It checked out at 0.07 per cent. The filter was again subjected to the static pressure test and was run up to 25 in. wg, the limit of our fan. It was again DOP tested and the results were 0.07 per cent penetration. No buckling or sagging of the frame was observed during this test. A similar test given to a filter made with CWS medium resulted in rupture of the medium at 16 in. wg. It is not our contention that the results of this test should be used as a criterion of filter strength, as we do not think that exactly the same stresses are put on a filter in operation as this filter was subjected to. We used cardboard to block off the face of the filter and this is quite different than dust-loading it. However, we do feel that it is an indication of the comparative strength of the filter papers. Mr. Walker, Dow Chemical Company, has shown some concern about the dust-loading capacity of glass media. We are not able to make tests to evaluate this as our only equipment is a DOP machine. However, we do feel that a filter with a greater efficiency and a greater strength should be able to catch and hold more dirt than a less efficient and weaker one. We do not think that filter paper thickness is a contributing factor to dust-holding capacity.

I learned before coming here that one of the AEC sites is considering the installation of a DOP machine. I know that one other site considered this at one time. We would certainly welcome such a development at all the sites. The sites are entitled to know what they are buying in the way of filter efficiency. Filters which are suspected of having been damaged in transit could be retested and filters which have been cleaned at the sites could be checked to determine if the cleaning process had damaged them.

DEVELOPMENTS IN THE MANUFACTURE OF ULTRA-AIRE SPACE FILTERS

Robert A. Bub
Mine Safety Appliances Company

Mine Safety Appliances Company has been in the Ultra-Aire space filter business since the U. S. Chemical Corps decided to stop manufacturing these units for government and allied uses. We worked very closely with the Chemical Corps, Arthur D. Little, Inc., and Hollingsworth and Vose to produce the standard space filter commercially.

This unit originally consisted of CC-6 filter media, corrugated kraft paper separators, rubber cement, and sponge rubber gaskets. It is interesting to note, in light of present discussions, that one of the sales features of this design is that it can be conveniently reduced to ashes by incineration for simple disposal. These units with all-glass filter web in place of CC-6 are available in sizes for 35, 50, 500, and 1000 cfm at a maximum initial resistance of 0.9 in. water. Special sizes can be fabricated if desired. This filter is shown in Fig. 1.

Very shortly after this item was placed on the market, several AEC sites indicated that there were installations requiring filtration equivalent to the standard Ultra-Aire space filter but at operating temperatures approaching 1000°F.

Mine Safety Appliances Company contracted with the Hurlbut Paper Company to develop filter media jointly capable of meeting the performance requirements outlined by the sites. This work resulted in a series of webs capable of filtering at elevated temperatures. Our No. 25310 or 1106-B glass filter web proved to be most practical for this application; in fact, it has less resistance and greater efficiency than CC-6.

Considerable time and money was spent to incorporate the material into a useful product. Long and involved tests were conducted with an endless series of high-temperature ceramic cements and adhesives that never proved completely satisfactory to our company.

Problems of compatability, aging, humidity, weathering, chemical resistance, expansion and contraction, handling, shipping, and storage were encountered.

These obstacles were overcome by devising a new patented folding procedure and using a high-temperature metallic binder. The resultant filter slug was installed in a mineral wool fiber housing for gasketing and installation purposes.

This filter is sold in a 50 cfm model (Fig. 2) that can easily be substituted for the standard units. It will operate at 1000°F and can be steam sterilized without damage. When tested with 0.3 μ DOP smoke, an initial efficiency of 99.97 per cent is guaranteed with a maximum pressure drop of 0.9 in. water. A survey of the potential market did not reveal sufficient activity to warrant development of larger production sizes.

As you all know, there is never a clean break between projects. During the development program on the high-temperature model, it was decided that the major need of the sites was a filter that would not contribute to a fire or explosion in an operating system or hood.

In case of fire, this filter should hold the material accumulated to date and prevent distribution of collected harmful particulate matter throughout the duct system or into the atmosphere. The filter would be replaced after the emergency has been brought under control.

With this new goal before us, substitutions were made in the original filter design to accomplish the desired item:

1. Fire resistant plywood manufactured in accordance with applicable military specifications was used for commercial fir.
2. Glass web with but 5 per cent organic material was used in place of CC-6 that has 85 per cent organic. In actual weight, the full content was reduced from 10 lb to 0.2 lb because of difference in total weight of media.
3. Mineral fiber separators were used instead of wholly combustible kraft paper.
4. Ceramic fiber gaskets were used in place of sponge rubber.
5. A more fire-resistant adhesive was used in place of the original material. We are still working to improve the fire-resistance of the adhesive used.

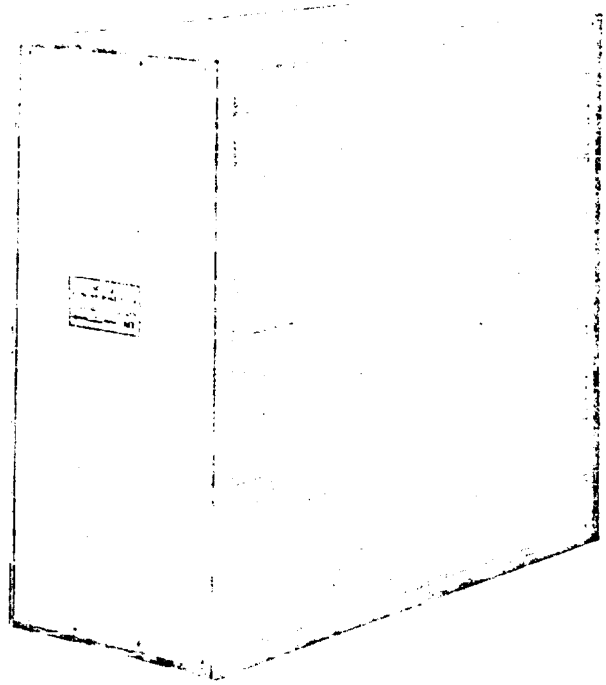


Fig. 1—Ultra-Aire space filter.

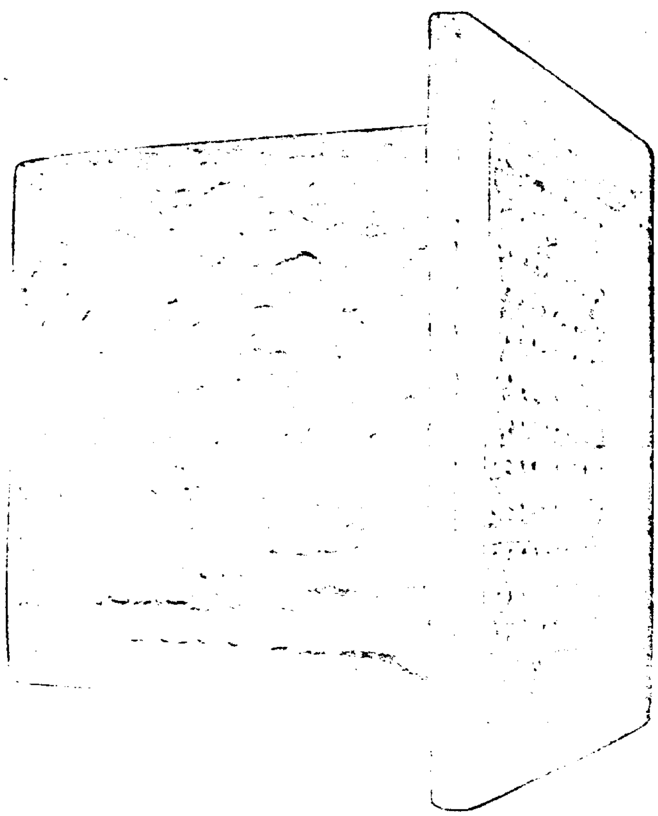


Fig. 2—High-temperature filter.

Results of tests conducted by MSA and AEC people are indeed encouraging. Data will probably be revealed in later papers on this program. These units, shown in Fig. 3, are available in 35, 50, 500, and 1000 cfm models as well as special sizes.

Figure 4 is a graph of pressure drop in inches of water vs cfm free air for all Ultra-Aire space filters in the sizes listed.

We have a continuous development program to improve performance of our Ultra-Aire space filters. Work along this line is being concentrated on reduced cost, increased efficiency, lower resistance, better sealants, and extension of filter life.

Along with Ultra-Aire space filter work MSA is designing, developing, and marketing special filters for particulate, gaseous, and liquid filtration. We have a series of catalytic filters for removal of gaseous contaminants, several liquid filters, and a long list of filter media for particulate problems.

The limited presentation time has made it necessary to give you a condensed version of our work in the filter development section of Mine Safety Appliances Company. This work is varied and very interesting to our company. It is hoped that the information presented was sufficiently useful to the extent that we will have an opportunity to discuss your specific filtration problems in the future.

FIRE-RESISTIVE FILTER PROGRESS AT HAPO

Don J. Keigher
Hanford Operations Office

Since the early days of the atomic energy program, safety and fire protection engineers have had increasing concern for the fire hazards of the highly combustible type high efficiency filter, particularly when used in large contiguous banks. Since 1951 the Hanford Works—the General Electric Co. and the AEC's Hanford Operation Office—have actively pursued a program of filter studies and testing, and have promoted the development of a less hazardous filter at every opportunity.

In this panel we will report on progress or experience gained at Hanford since the last Air Cleaning Seminar. This report will be given on three aspects of the problem; operating and ventilation, industrial hygiene, and fire protection. Mr. James H. Palmer, of the Air Balance Unit, Chemical Processing Department, General Electric Company, will report on the moisture and fire tests made in the last eighteen months. Mr. Frank E. Adley of the Industrial Hygiene Group, Hanford Laboratories Operation, General Electric Company, will report on a significant fire that occurred in his operation. I will give a review of our criteria for a fire-safe filter. I would like to add, before we start, that the cooperation of the various groups of G.E. and AEC and particularly of the three of us represented on the panel has been excellent, and what progress we have made can largely be credited to that spirit of common effort.

I was fortunate to participate in the Fourth Air Cleaning Seminar held at Argonne National Laboratory in 1955. At that time we attempted to review the broad field of Fire Considerations in Filter Design. We reviewed the design growth of high efficiency filters, as well as ventilation systems in general, from a fire protection and fire safety viewpoint.

We noted and it is still remarkedly true that no major fires have developed in filter banks using the old and still most common cellulose-asbestos type units we usually refer to as the CWS-6 type. We reviewed some seven fires that had occurred and were documented through investigation reports, and although we said at the time none had occurred during the war years under the Manhattan Engineering District, we have found that is not true. I cannot stress too strongly the importance of investigation and documentation of even seemingly minor incidents such as filter fires when a solution for such a problem is being sought. These fires occurred at varying sites, under various AEC contractors, and under varying conditions, pointing up a serious universal fire problem in filters that needs serious attention.

I think it important that we stress the need for good fire protection engineering design throughout ventilation systems before we get into the fire aspects of the filters themselves. An excellent guide for the over-all firesafe design of ventilation systems is the National Fire Protection Association's Code No. 90A, "Standards for the Installation of Air Conditioning and Ventilation Systems for Other than Residence Type." Most of you are familiar with the red-jacketed National Fire Codes and have used them before. I cite this particular code, and cannot overemphasize its general usefulness in design, because it would be folly to spend many thousands of dollars for fire-resistive filters and have them installed in systems that have light plywood plenum chambers, easily shattered duct work, lack of fire dampers, and all the other deficiencies that all too often prevail in these systems.

At the 1955 meeting we presented in our opinion what was the ideal criteria for a firesafe high efficiency or absolute filter for use at our AEC installations or at any installation where similar filtration is necessary.

We have revised our criteria with subsequent test experience and actual fires that have occurred. I also acknowledge the work done by Humphrey Gilbert of our Washington Safety and Fire Protection Branch who has devoted considerable time to this filter fire problem, has visited most of your facilities compiling information on the subject, and has worked closely with the manufacturers in recent months.

These criteria for a firesafe filter are premised on preventing the two fundamental effects fires in filters can produce. (1) The release of highly radioactive materials into vital buildings and areas, with subsequent decontamination costs and time delays. (2) Equally serious and sometimes overlooked is the rapid release of tremendous heat energy in confined spaces which results in wholesale fire destruction to contents and the structure itself.

Using our previous criteria as a guide we must note some fundamental corrections. We were striving, and hoping for a fully noncombustible filter. We still are, but we will use the more correct term fire-resistive filter when referring to this unit, since for the present at least we are willing to accept some combustible materials into our ideal. We also must point out that there are very high-temperature units available that can withstand temperatures in the range of 1500°F to 2000°F. We are not talking of such a filter although there is a need for such a filter. We are talking of what might be called an intermediate high-temperature filter say in the range of 500°F to 1000°F, and we will not ask for an oven test of the entire unit. Only certain components need to be oven tested.

We do ask that this filter remain substantially intact when subjected to vigorous fire and even though its filtration abilities break down that it continue to act as a barrier and not contribute to the fire.

It is our opinion that the practical criteria for a firesafe filter should be:

1. *Frame.* The frame itself should be $\frac{3}{4}$-in. plywood, preferrably exterior grade of an impregnated fire retardant type. This type plywood is generally available and quality controlled by a federal specification and/or the U.L. labelled type. For best stability we recommend corner butt joints and screws, or rabbetted joints with double nails.

Although fire tests and actual fires indicate the wood frame was not a prime fuel, it is hoped that an acceptable noncombustible frame will be found some day that is comparable in price.

We feel the added cost of the fire retardant, and this is the impregnated not surface-painted type plywood, is justified because this is the bulk of the burnable material left in the improved unit.

2. *Filter Media.* The all-glass fiber generally used by all the manufacturers is satisfactory from a fire point. It must be capable of withstanding at least 75 per cent humidity, 10-in. water pressure differential, and have an initial capacity of 10 sq ft of contact area at 0.85-in. water gauge pressure drop. A maximum of 7 per cent binder is recommended.

Although not recently tested we believe the type A glass-asbestos paper, the type A. D. Little Co. developed for AEC in the early 1950's, will also be adequate firewise, but we have had very little experience with it.

3. *Loading, Capacity, and Efficiency.* The loading characteristics must be comparable to or better than CWS-6 media. We expect a minimum efficiency of 99.95 per cent with the standard DOP penetration of 0.05 per cent for 0.3-μ diameter homogenous particles. This would be in service in 75 per cent relative humidity air. Mr. Palmer has made some succesful moisture tests with some specially made filters.

4. *Separators.* We strongly feel separators should only be of noncombustible, nonmetallic materials. Flame treated paper readily loses its fire resistance even in dry atmospheres. The thin aluminum type rapidly deteriorates in acid and wet chemistry atmospheres causing rapid loading of the filter media by the aluminum salts. Also the aluminum dividers (melting point, 1218°F.) literally collapsed in our fire tests. The mineral wool (asbestos) type separators have given very good performance firewise, also the fiber glass type, and we are confident the ceramic will be very good too. Our tests also show that in mounting the filters they should be placed so the separators are vertical, not horizontal.

Now we get to the two components that need further work and study but we have made arbitrary recommendation to expedite replacement.

5. *Adhesives.* We recommend an adhesive, that when cured shall resist a minimum temperature of 250°F for eight hours (this is a separate oven test, not as part of whole filter). If ignitable above this temperature, it must be self-extinguishing and shall meet all general operating conditions without change in physical properties and without loss of seal.

There are numerous compounds proposed and some used such as polyester resin that ignites in the range of 400°F to 600°F and when it does it burns violently. A chlorinated resin shows promise and a nitryl rubber adhesive gave acceptable performance in our fire tests. A whole family of other adhesives are still to be studied.

6. *Gasket.* We have decided that the neoprene sponge rubber $\frac{1}{4}$ in. thick is satisfactory at present mostly because of the angle iron framework in which Hanford filters are placed. A noncombustible gasket is available and quite satisfactory if competetive costwise. Naturally this gasket must cover the front and rear edges with tight butted joints at the corners.

In summary of this brief review of our criteria for a firesafe filter I might report that a purchase of over 1000 units of essentially this fire-resistive filter is now in the making. We hope to report at the next Air Cleaning Seminar our field experience with this type and its possible successes or deficiencies.

In closing I am moved to remark that I feel that my job, as a fire protection engineer, is about completed in this filter fire problem. The numerous references to fire incidents and concern for fire hazards associated with the air cleaning operation at many AEC facilities that have been made in papers presented here indicate that our first mission to promote concern for the fire problem is fulfilled. Also many of you are working on the solution to these problems. And with availability of the fire-resistive filter we mentioned as a standard commercial item almost at hand, the large filter bank fire should be a problem of the past.

MOISTURE AND BURNING TESTS OF SPACE FILTERS

J. H. Palmer
General Electric Company, Hanford, Wash.

Many tests have been conducted at the Hanford Plant in an effort to obtain an all-purpose moisture- and fire-resistant space filter, capable of extremely high collection efficiency in removal of submicron particles from exhaust gases and systems.

Frequent reports of fire incidents occurring at various AEC installations, in which space filters are involved, and minor incidents occurring in our own plant, have made the need for the fire-resistant filter urgent.

Fire-resistant filters are available, but in our experience, they have broken down during the moisture tests. Some have deteriorated in actual use by "weathering" under normal atmospheric conditions. Then again, the best fire-resistant filters do not meet our high efficiency demand.

The existing fire-resistant filters contain a heavier or thicker filter medium, thus reducing the number of folds, or filtering area, per filter. This, in turn, will reduce the life of holding capacity of the filter.

Cost is another consideration. Completely fireproof filters no doubt could be fabricated but the cost per unit would be prohibitive. This is a big factor where hundreds of filters are in use.

Life or holding capacity is another big factor, as replacement of filters is a costly procedure involving many man-hours, sometimes under extremely low time limits. Extreme care must also be used when changing these filters because of endangering personnel and facilities with exposure and possible spread of contamination.

In our tests various manufacturers' products were used, the first object being to determine the available filter with the highest moisture resistance quality consistent with the high filtration qualities required. Flow capacity, construction, original pressure drop, and filtering area, were also taken into consideration.

One filter withstood our moisture tests in an outstanding manner. It met all requirements demanded of this type filter.

This resulted in our requesting the manufacturing company to modify their standard filter to the extent that the wood frame be fire resistant according to federal specifications and that the separators be of noncombustible material. Corrugated aluminum separators were disqualified.

As a result of previous tests of various manufacturers' products, this company's filter was chosen for development because of its better over-all moisture-resistant qualities, in addition to its equal or better filtering quality and construction.

This specially constructed filter is the best moisture-proof and fire-resistant filter so far tested by us. Tests to which this filter have been subjected are admittedly severe, but we feel were justified by the results obtained.

1 MOISTURE TEST APPARATUS

The test apparatus consists of a stainless-steel chamber, similar to a regular fan casing, with intake and discharge ducts. A rack is provided to hold filters up to and including a 24- by 24- by $11\frac{1}{2}$-in. size. Test ports are installed in the intake and discharge ducts and also at various locations in the chamber for purposes of measuring static pressures, drops, and flows. Wet steam is admitted at the intake where it is mixed with the incoming air to the filter or filters being tested. The apparatus is connected to an Aladdin Heating Co. type E.X. fan, with a rated capacity of 2000 cfm at 4 in. wg standard pressure (see Figs. 1 and 2).

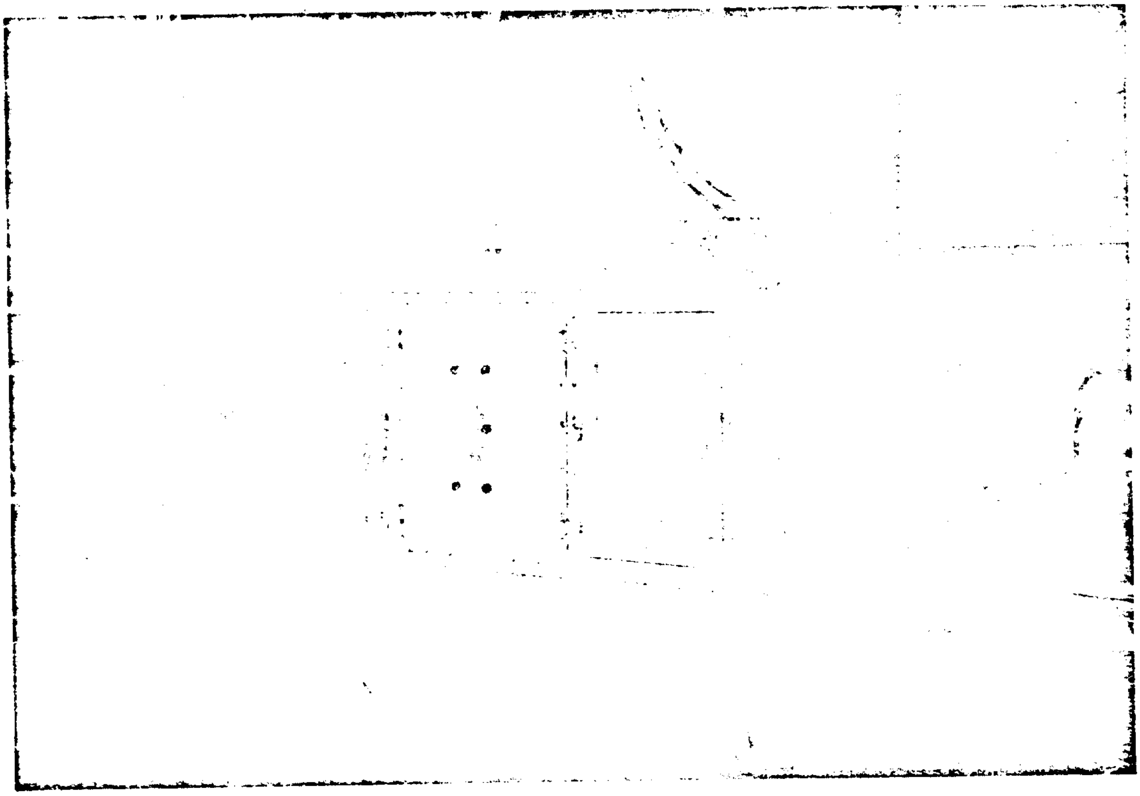


Fig. 1 — Moisture and capacity test apparatus.

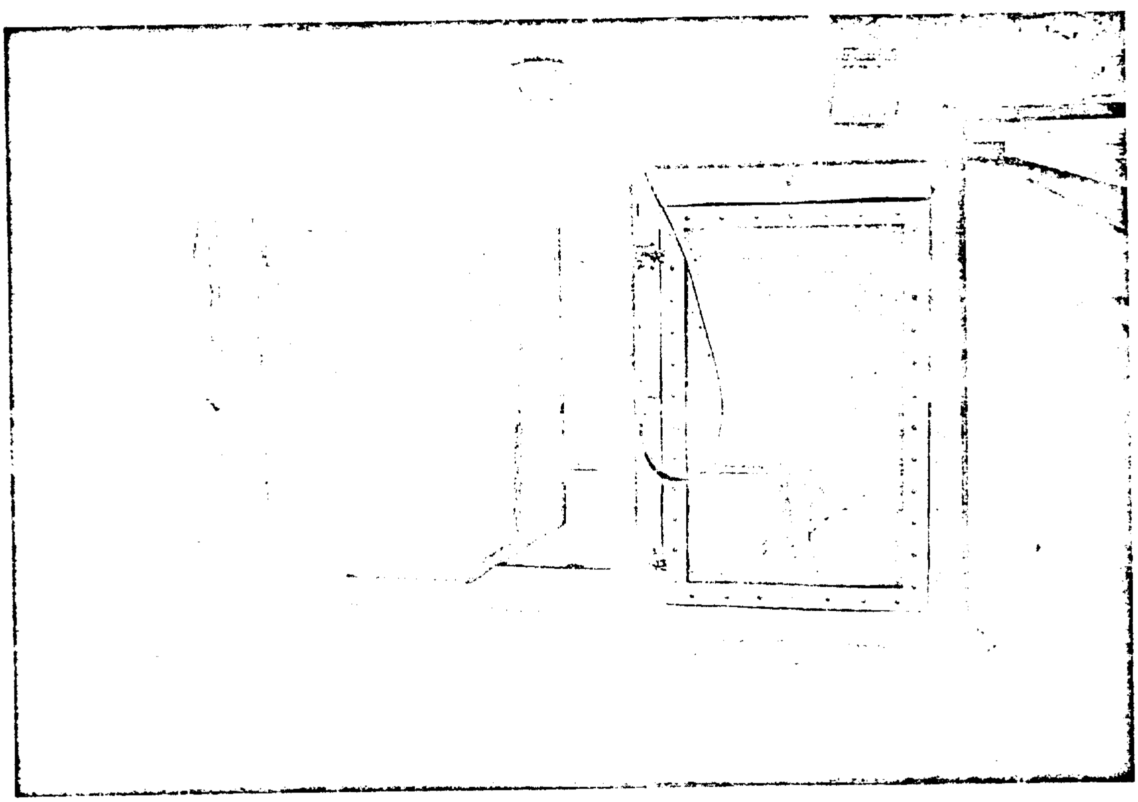


Fig. 2 — Moisture and capacity test apparatus, showing filter in position for testing.

2 BURNING TEST APPARATUS

This simple apparatus consists of a 1-ft 2-in. by 20-ft tube with transition from a 2-ft by 2-ft by 1-ft 8-in. open end box for holding the filter under test, fabricated in black iron. A damper to control flow quantity and a test port for static pressure and flow measurement are provided.

The tube is attached to a Lamb air mover, manufactured by the Lamb Mine Safety Appliance Company. The mover is a venturi, No. SE-63. The motive power is supplied by a large 90-lb air compressor.

A loose, fire-brick furnace was erected at the filter box intake. Excelsior and shredded paper were used as combustion material. The air flow passing through the filter was controlled at 1050 cfm, with a velocity of 260 fpm. Six thermocouples were installed at various locations on the filter, so that temperature readings could be taken during the course of the tests (see Fig. 3).

Photographs were taken at various stages of the tests and are included in this report.

Combustion tests of the components of two manufacturers' filters were conducted by the Industrial Hygiene group, under the direction of F. E. Adley, the results of which corroborate our findings.

3 MOISTURE TEST

To speed the test and to hasten possible breakdown of the components, the filter was alternately exposed to completely saturated air for periods of 48 hr and drying periods of 24 hr, with a continuous flow passing through the filter for the duration of the test. The wetting and drying cycles were repeated twice.

At the start of the test, with a dry filter, an air flow of 1200 cfm was obtained with a pressure drop across the filter of 1.10 in. wg. The gradual saturation of the filter reduced the flow to 107 cfm and increased the pressure drop to 4.5 in. wg.

At the end of each drying cycle the pressure drop would automatically return to the original 1.10 in. wg with its corresponding flow quantity.

During and at the end of the test the filter was carefully inspected for breakdown and deformation. The only effect noted was a slight compression of medium where it folded over the separators on the intake side of the filter.

This filter, after passing through the above test, and being thoroughly dried out, was later used in a preliminary burning test, the results of which are described in this report (see Figs. 4 and 5).

The other filter tested completely failed on the first wetting cycle.

4 BURNING TESTS

4.1 Test 1, Preliminary

A preliminary test was conducted, using the filter which had passed through the moisture tests, to test out the apparatus and to perfect the test procedure.

This 24- by 24- by $11\frac{1}{2}$-in. filter, one of the originally modified filters, was constructed as requested. The frame was composed of plywood which had been externally treated with fire-protective coating. (Since receiving this filter, this manufacturer has further improved the filter by constructing the frame of impregnated plywood.)

As this was a preliminary test, extreme and minimum firing was tried. Small handfuls of excelsior were placed against the filter and fired with little or no result. The amount of combustibles were finally increased so as to cover approximately three-fifths of the filter as shown in Fig. 6.

The firing material in this test was placed directly against the filter and fired. Within seconds the temperature at a point approximately 8 in. from the bottom center of the filter was

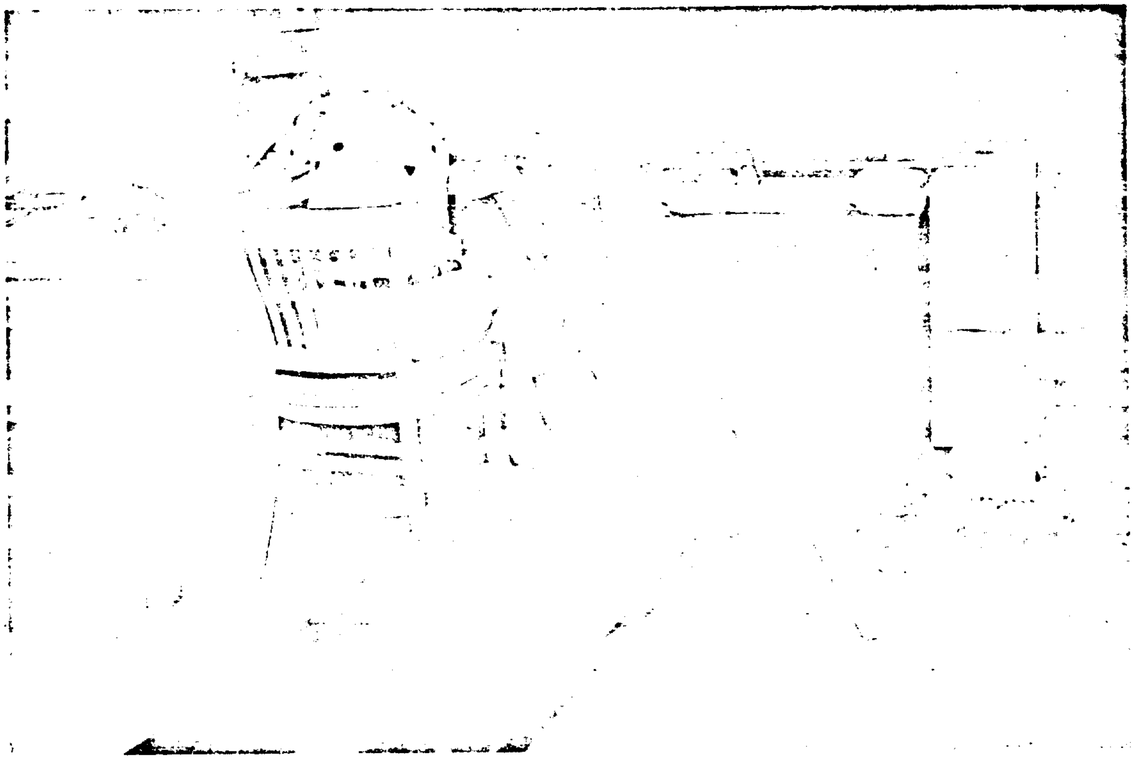


Fig. 3 — Downstream side of burning test apparatus, showing multiple temperature recorder.

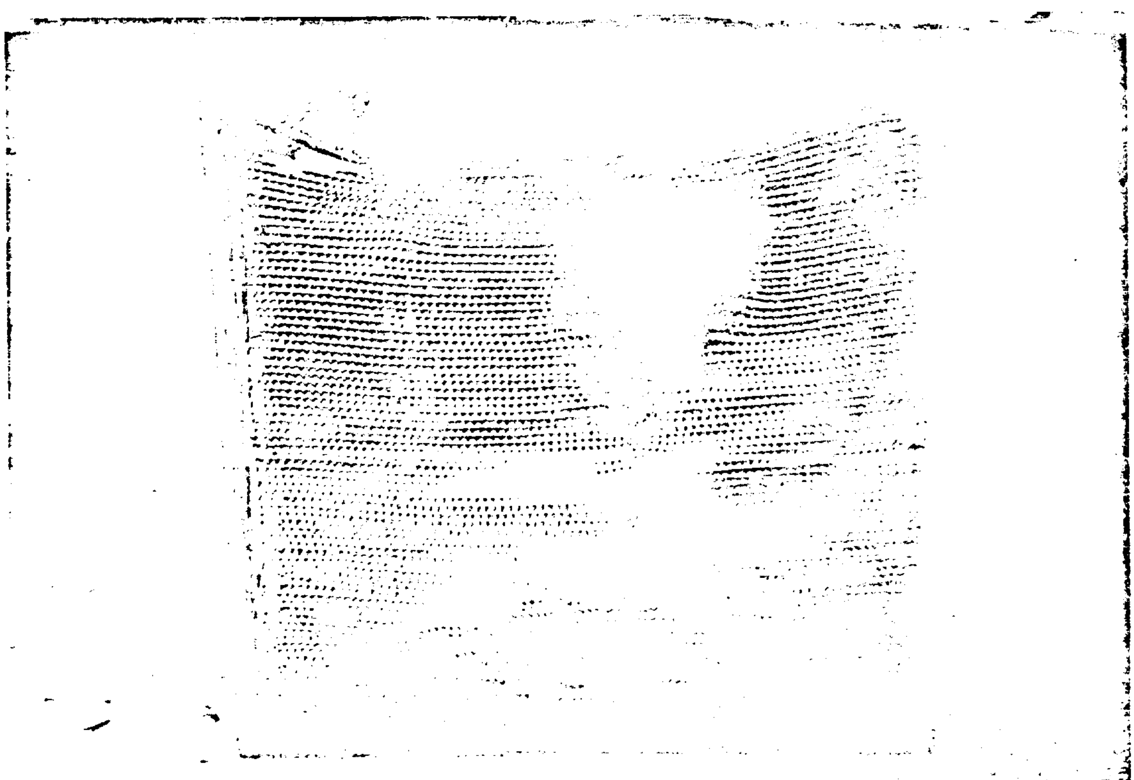


Fig. 4 — Result of fire test on specially modified filter. Side exposed to fire. Filter was constructed of externally fire treated wood frame and passed through two burning tests in addition to moisture tests.

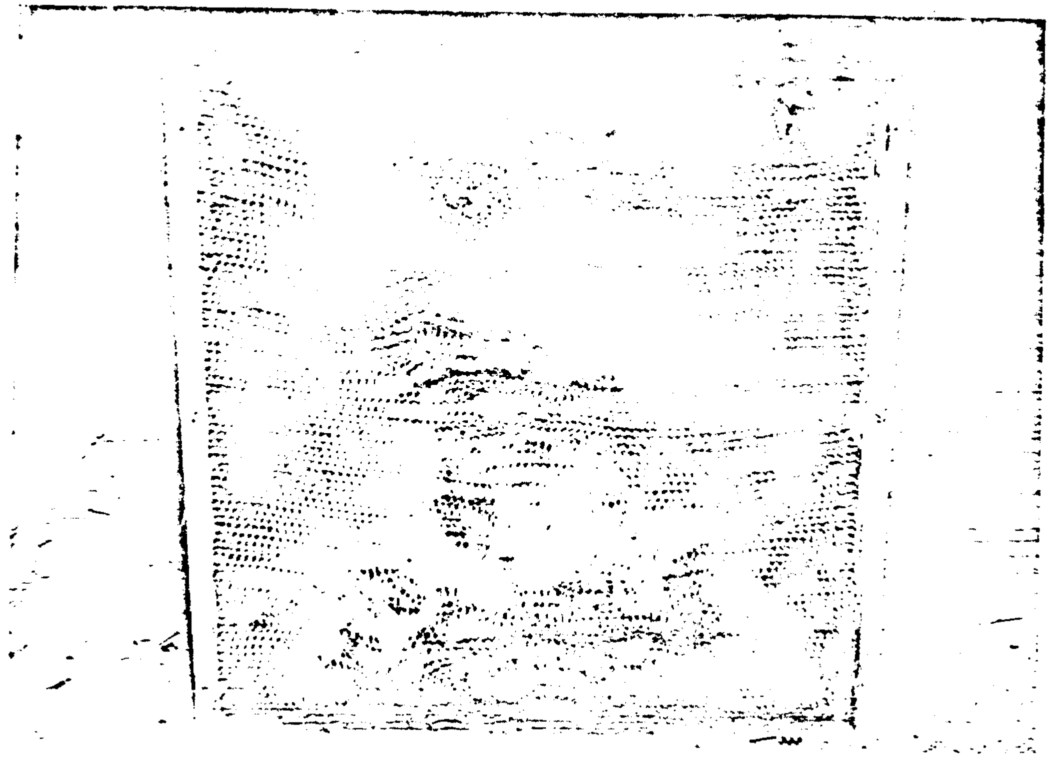


Fig. 5—Same filter as in Fig. 4, showing downstream side of filter.

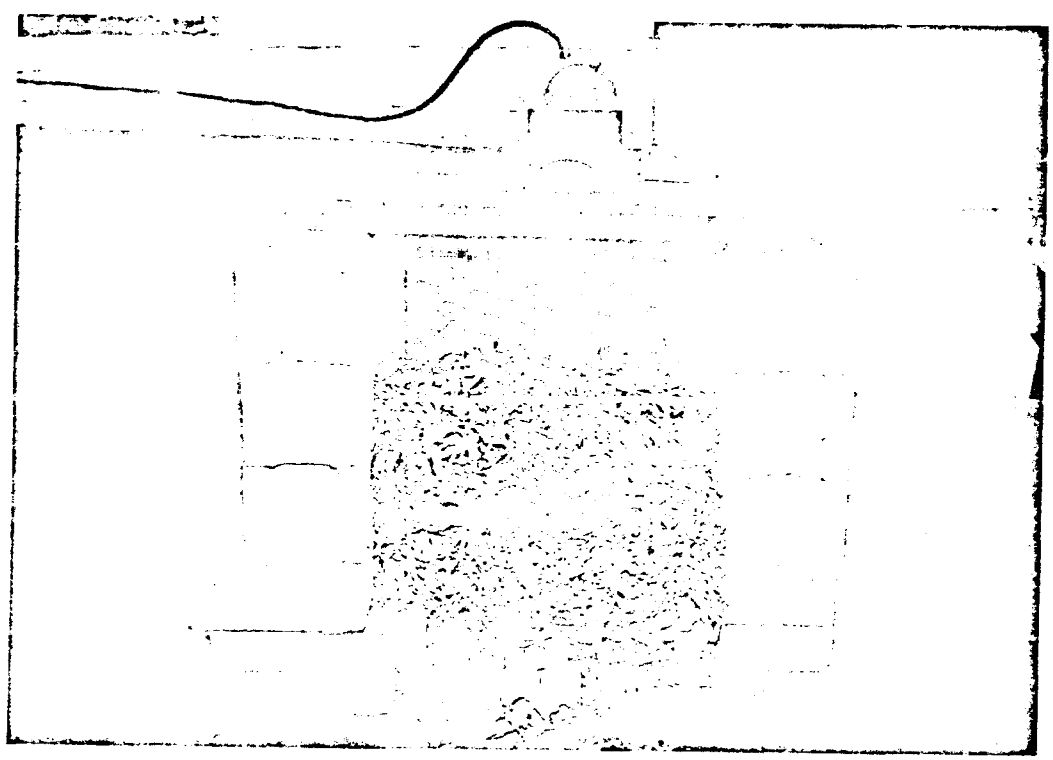


Fig. 6—Impregnated wood frame filter immediately before firing. Chicken wire screen, 4-in. mesh, not present in previous tests.

read at 950°C, as sensed by the thermocouple located at this point (see Fig. 7). The next highest temperature, 600°C, was reached at a point approximately 8 in. from the top center of the filter. The temperature of the wood frame at the bottom of the filter was recorded at 150°C. The temperature of the adhesive was measured at 185°C and started to smoke at this temperature. Other point temperatures were insignificant.

It will be noted (see Figs. 4 and 5) that the wood frame at the bottom and center of the filter has been completely burned through and that the filter medium is badly charred at the extreme burning point. Also it can be noted that the side frame is charred but not burned through. This was no doubt due to angle irons being placed on the sides of the filter just barely covering the gasket.

To further perfect the test, this same filter was turned 180° and refired. This time a piece of masonite was placed in front of the gasket material at the bottom of the filter (top of filter in previous test). The exhibits show that this prevented the frame from burning through even though it was subjected to the same temperature and conditions as in the previous tests.

Note that the top of the filter in Figs. 4 and 5 was the bottom of the filter in the first burn test.

We feel that this preliminary test was of considerable value, inasmuch as it demonstrated the significant comparison between fire-treated wood frames and impregnated wood frames, as shown in the tests which followed.

4.2 Burning Test No. 2

The filter used in this test was constructed of the same materials as the filter in the previous tests, except that the frame was constructed of impregnated wood.

This test was nearly identical to the first test, the exceptions being: a 4-in. chicken wire screen was placed approximately 6 in. from the face of the filter and angle irons were placed at top and bottom of the filter as well as at the sides.

The chicken wire screen kept the bulk of the firing material from actual contact with the filter, but not the flames or burning fragments. The placing of the angle irons around the filter closely corresponds to actual installation.

Thermocouple sensing lines were installed as in previous tests, except that No. 3 was placed approximately 3 ft downstream from the filter. Combustibles containing shredded paper and excelsior were placed in the firing chamber as in the previous tests (see Fig. 4) and fired. Figures 8 and 9 were taken during this test.

As in the previous test, the highest temperature (760°C) recorded was at point No. 1, approximately 8 in. from the bottom of the filter, and the next highest (650°C) at point No. 2, approximately 8 in. from the top of the filter. Temperature of the downstream air was read at 410°C at maximum. Point No. 5 indicating temperature of the adhesive showed 185°C, and the wood frame at the bottom of the filter reached a temperature of 260°C.

The accuracy of the temperature readings is not positive as the multiple recorder was hand operated. It is quite possible that higher temperatures were attained at the various points, but were not detected.

This filter withstood the test in an excellent manner as shown in Figs. 10, 11, and 12. Figure 12 shows the main points of break-through. A flash bulb held behind the filter intensifies the holes caused by charring and air velocity.

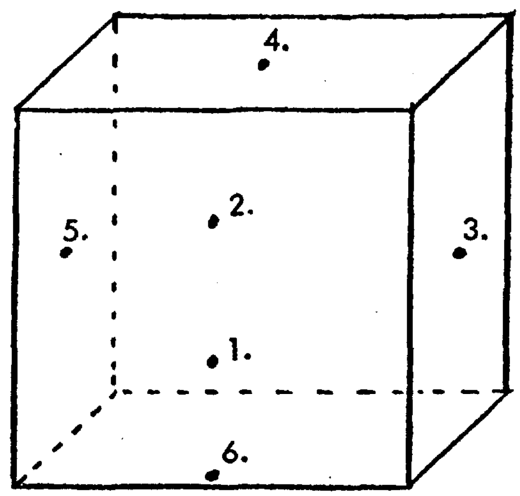
The impregnated wood frame did not break into flame. Also, it held its shape and dimensions. The rubber gasket was shriveled at the edges, but where covered by the angle irons showed little effect. The adhesive bubbled, but did not flow or flame. The adhesive did show signs of charring where exposed to extreme temperatures.

4.3 Burning Test No. 3

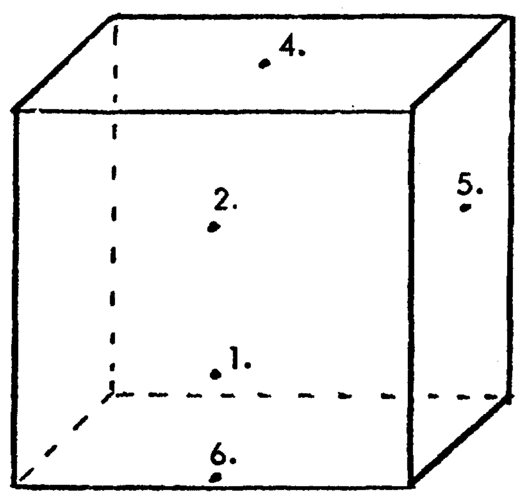
This test was conducted to compare the effects on the modified filter with that on a filter which has been accepted as being fireproof.

Figures 13 and 14 graphically show the comparison.

(Text continues on page 65.)



Thermocouple Locations—1st Test.



Thermocouple Locations—2nd Test.
Point No. 3 Placed In Downstream Duct

Fig. 7—Thermocouple locations.

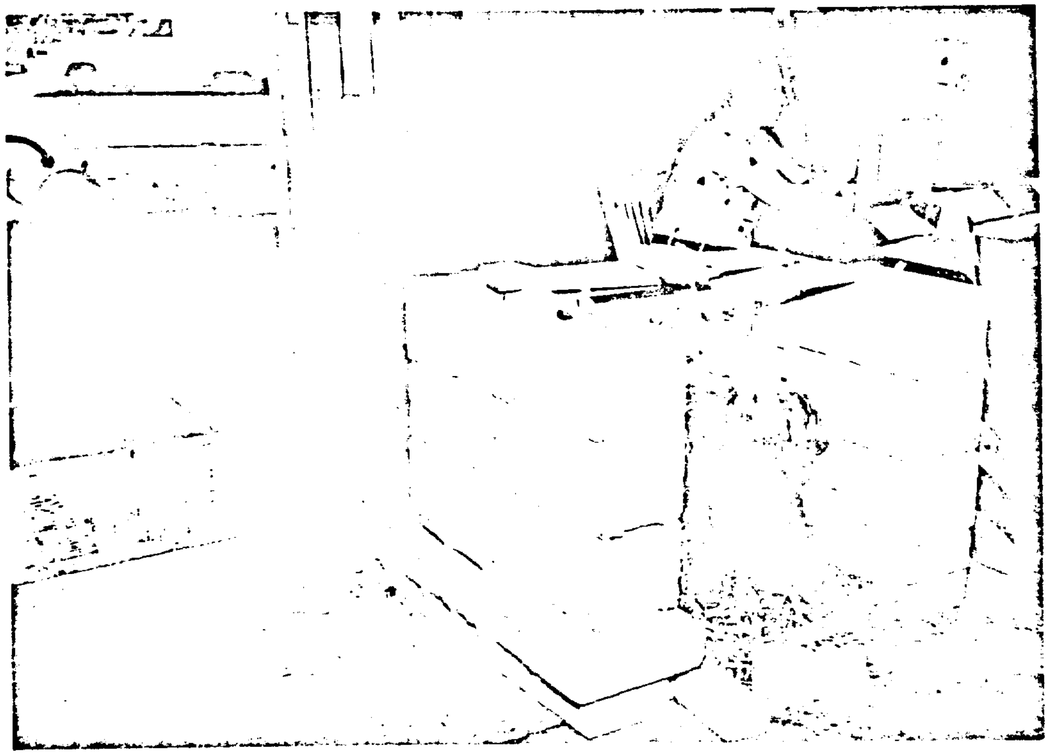


Fig. 8—Same filter as in Fig. 6 with fire started.

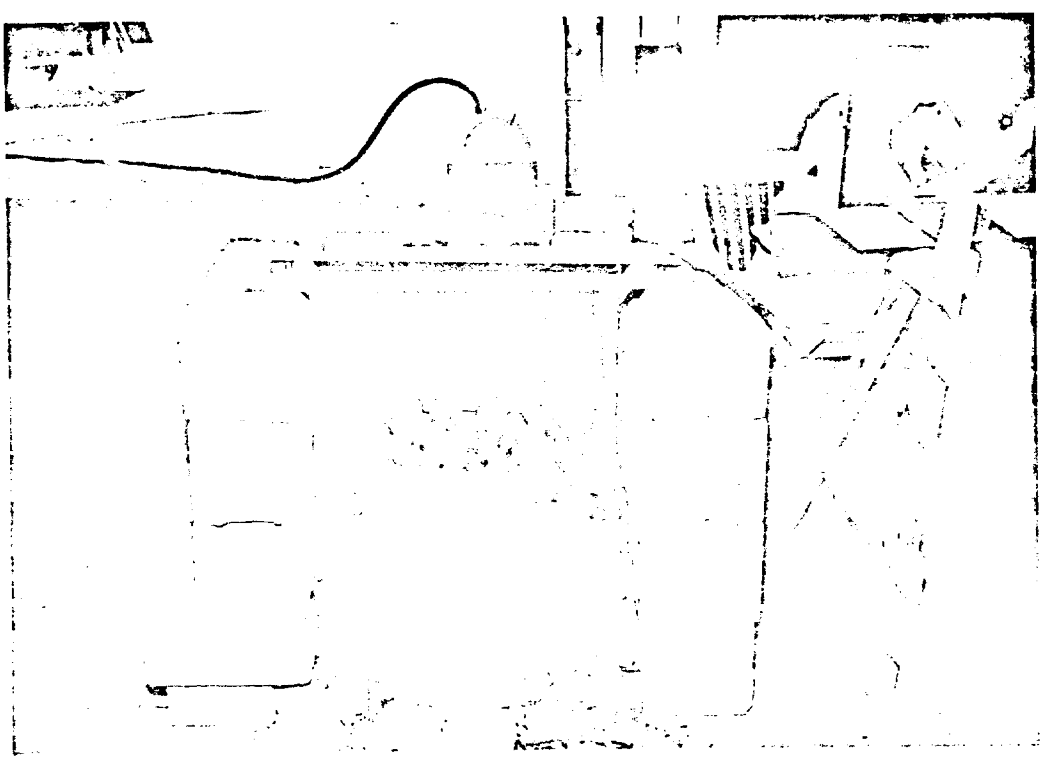


Fig. 9—Same filter as in Fig. 6 with fire half burned out.

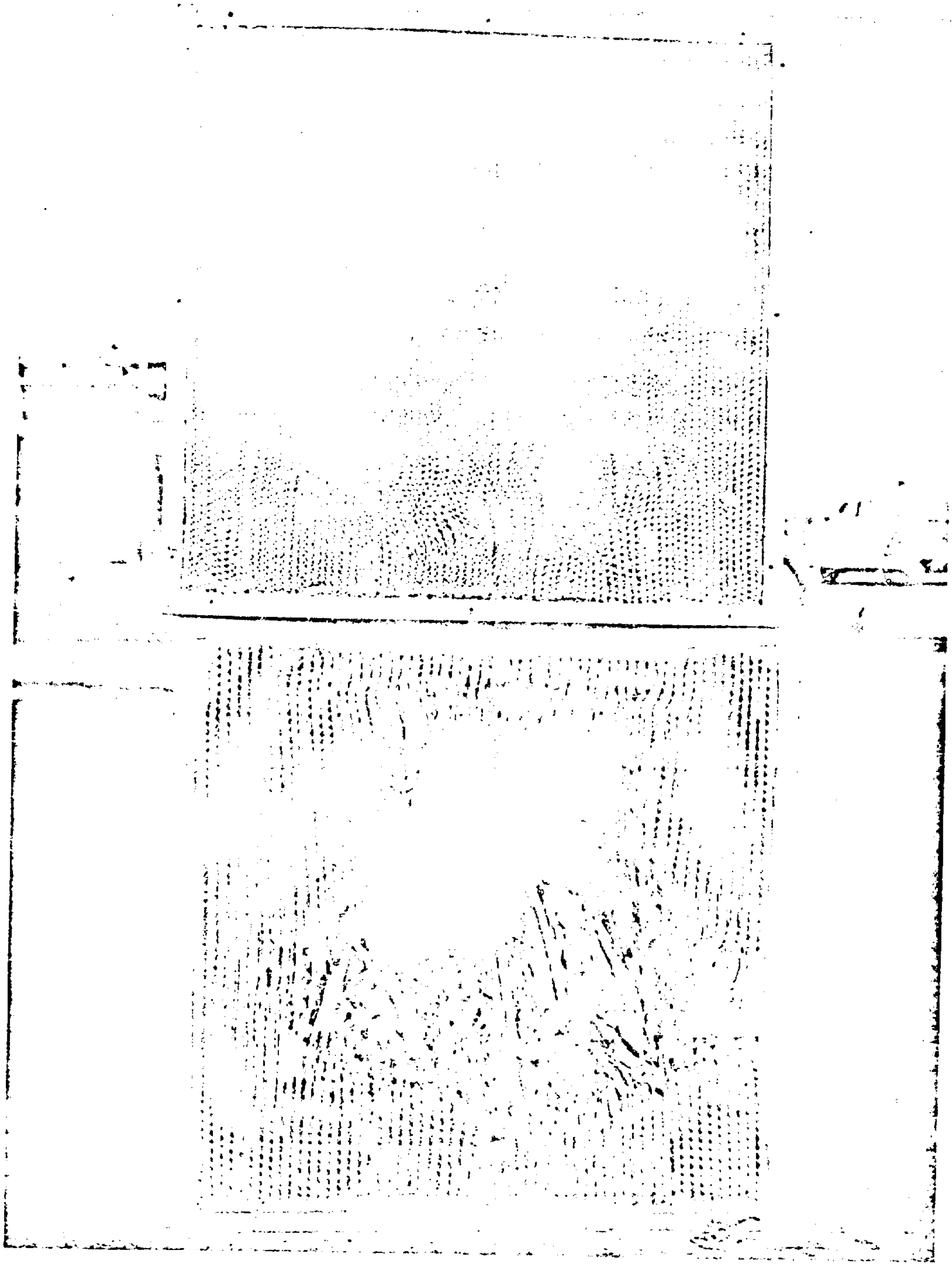


Fig. 10 — Comparison of filters after test. Top, modified filter; bottom, accepted fireproof filter. Sides exposed to fire, accepted fireproof filter upside down to position in test. Gaskets on both filters show little or no effect from burning test.

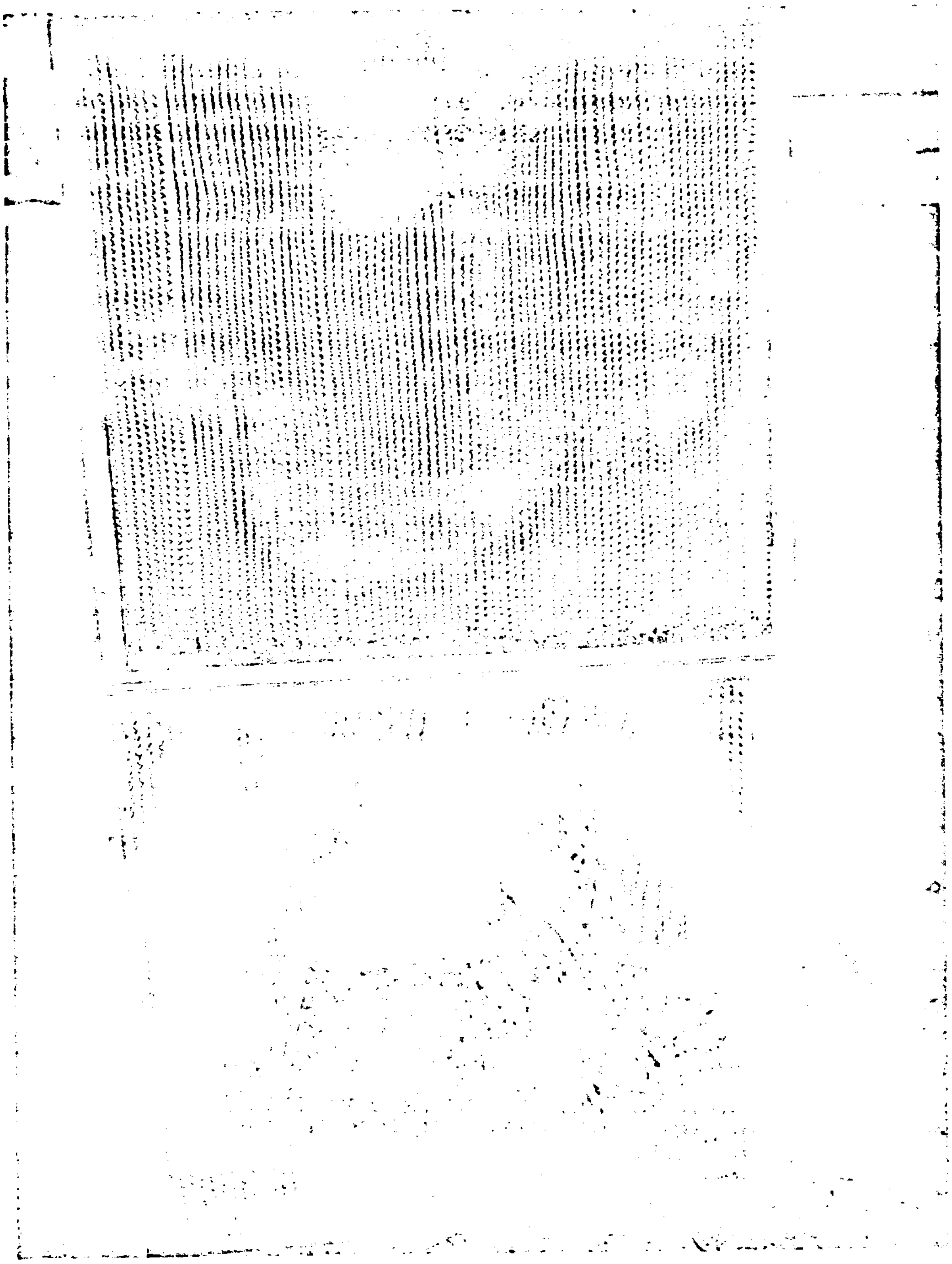


Fig. 11 — Comparison of same filters as in Fig. 10, showing downstream side of filters. Both filters are upside down to positions in test. Gasket is gone on modified filter where exposed to extreme heat; no effect on other gasket.

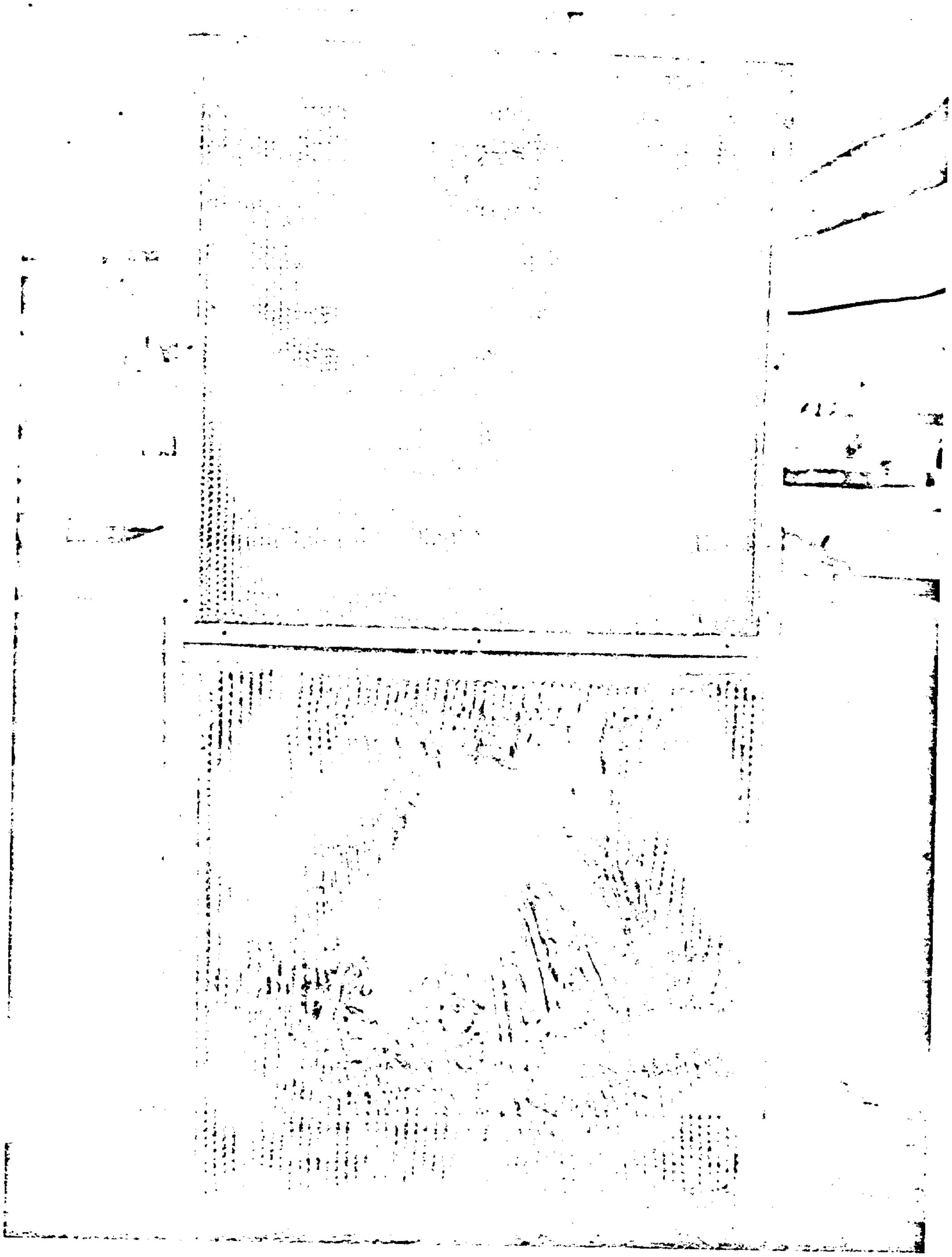


Fig. 12 — Same filters as in Fig. 10 with flash bulb held at back of modified filter to make breakthrough more pronounced — two white spots.

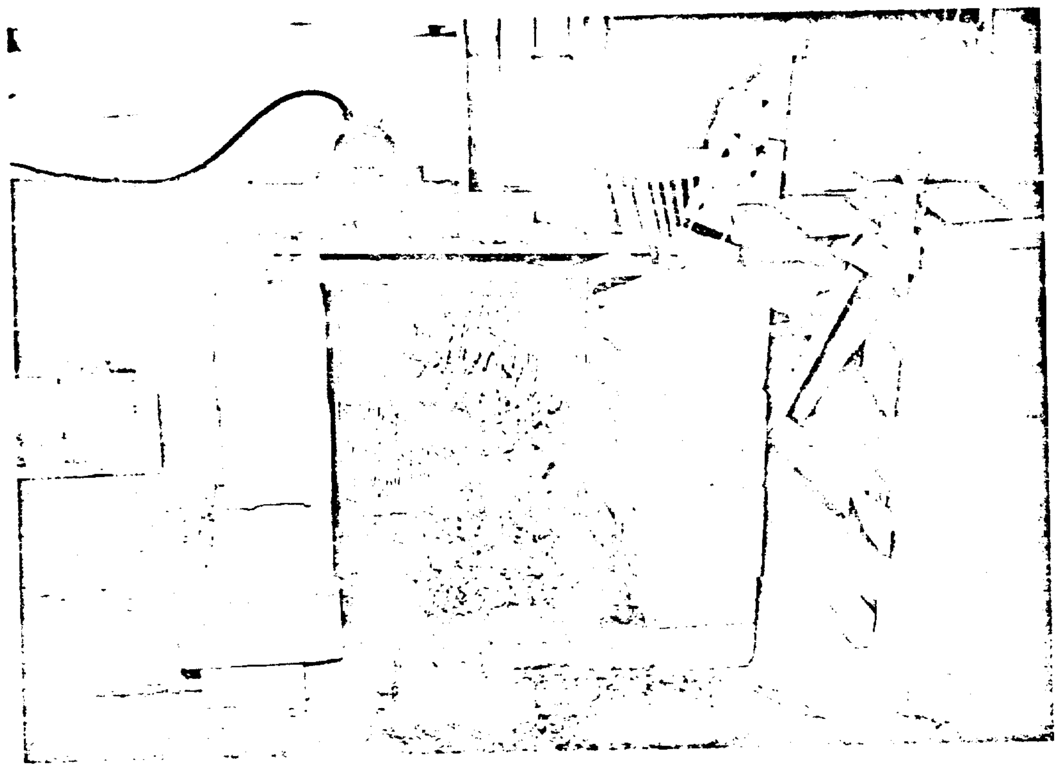


Fig. 13—Accepted fireproof filter under test with fire nearly burned out. Note hole in filter.

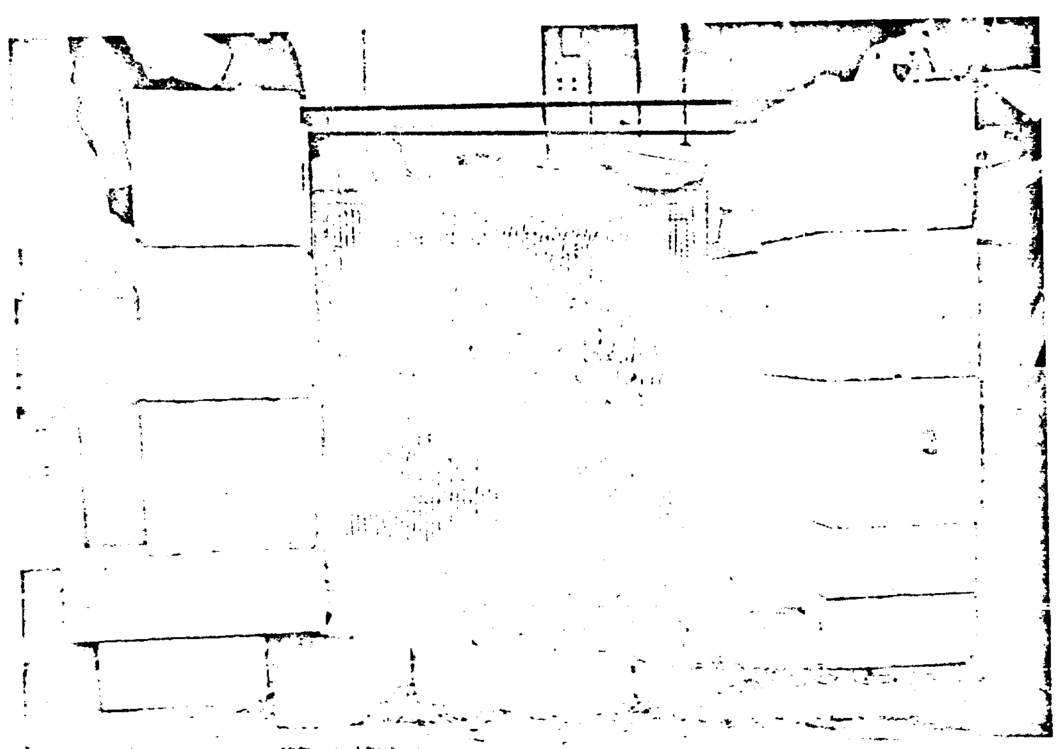


Fig. 14—Same filter as in Fig. 13 immediately after fire was out.

The accepted fireproof filter was subjected to as near as possible the same conditions as the previous filters under test. The same amount of combustibles was applied and the same air flow quantity maintained.

This filter decomposed so rapidly that very few temperature readings were taken. The aluminum separators melted within seconds and without the support of the separators the filter medium disintegrated. Wads of aluminum "wool" were found at the extreme end of the downstream duct, near the venturi tube.

APPLICATION OF FIRE-RESISTANT AIR CLEANING FILTERS AT HAPO

F. E. Adley
Hanford Atomic Products Operation

The need for fire-resistant filters for air cleaning at Atomic Energy Commission installations where radioactive air contamination is involved has been evident for many years. Excessive amounts of airborne radioactive substances, which may be present in ventilation air during a building or process fire, or from the normal accumulation or loading of radioactive substances on filter faces, indicate the necessity for these filters to remain intact during fires. The absence of such control provides a serious source of building and environmental contamination as well as potential exposures to humans. Combustible filters for cleaning ventilation air of radioactive particulates have periodically been the source of noteworthy environmental contamination, expense, and time loss.[1,2] Such filters, however, due to their acceptable air cleaning performance characteristics, have been and are still used widely for such applications.

At Hanford, Absolute filters are used in numerous installations at production and laboratory sites. These two applications differ notably, particularly with respect to the quality of the filter loadings encountered. At process facilities such filter systems are normally designed to remove fairly well identified contaminants. That is, identified to the extent that the particulates, for example, may be predictable fission products at known concentrations. This aspect was covered well by Mr. Palmer's presentation. The use of these same filters for research and development laboratories subjects them to a potential loading of almost any conceivable combination of pyrophoric, corrosive, or toxic chemicals in addition to the radioactive loading. Such loadings can produce any degree of fire hazard up to those of spontaneous ignition from substances such as perchlorates. Two instances of laboratory fires at Hanford exemplify this problem.

The first instance involved an experiment wherein 1 cc of anthracene was being heated in a glass flask by a Bunsen burner. During the course of this heating the vapors forced the stopper from the flask and some of the material apparently entered the air stream. This particular filter installation comprised a 2-ft by 2-ft by 11½-in. CWS filter unit preceded proximately by a glass fiber roughing filter. Very little time elapsed before the filters were burning and were extinguished with difficulty. This system is all stainless steel with the exception of the filters, consequently, the fire was confined to the hood assembly.

The second fire was in an identical hood and originated from the wet-ashing of vegetation in concentrated nitric acid. On reaching dryness for the third time, the rapid oxidation of the nitrated organics resulted in a flash fire. Once again the filter unit was quickly ignited and burned with such vigor that the stainless steel ducts in the attic space above were aglow for several feet. Considerable difficulty was encountered in extinguishing this filter fire although it was similarly confined to the hood assembly.

Several observations were apparent in these two instances with respect to the factor of flammability.

1. Filter units employed in ventilating systems should be constructed of nonflammable materials. This also applies to roughing filters.

2. It is imperative that all components of the exhaust ventilating system and all attachments thereto should be constructed of nonflammable materials.

3. If design permits, the Absolute and roughing filters should be separated by several feet since organic substances such as lint can accumulate on the roughing filter and are capable of being ignited.

4. The behavior or intensity of combustion in an airstream having a velocity of several hundred feet per minute is tremendously accelerated. This increases combustion temperatures, with attendant problems, and additionally increases the problem of extinguishing the fire.

These filters are being replaced as the development and supply of fire-resistant Absolute filters permits.

To understand better various applications of fire-resistant filters at Hanford, typical filter units were subjected to full-scale burning tests, as discussed by Mr. Palmer, and in addition, components were submitted to laboratory combustion tests by the Industrial Hygiene Operation in August 1956. Most of the tests were conducted in a muffle furnace in the presence of air unless noted otherwise. The findings from tests on two makes of filters are presented in Table 1.

Table 1—FINDINGS FROM TESTS OF TWO MAKES OF FILTERS

Filter	Component	Remarks
A	Impregnated wood frame	Charring commenced and smoking at 480°F. Started to turn to white ash at 1020°F. Complete ashing at 1440°F. Did not flame at any time.
	Fiberglas filter medium	Flamed briefly when ignited, probably due to binder. Darkened at 760°F, then turned white as carbonaceous material ashed. At 1470°F it shrank to about 50 per cent of its original size.
	Asbestos separator	Darkened to brown color in a Meeker burner flame. Became extremely brittle at 1700°F, but did not change its shape.
	White sponge rubber gasket	Material becomes tacky and smokes at 360°F. Melts at 540°F, hardens into a dark solid at 760°F, and turns to a white ash at 840°F.
	Adhesive	Becomes tacky and smokes at 360°F. Charred and bubbled at 630°F. Turns to dark, firm mass at 750°F, and to a white ash at 840°F.
B	Fiberglas filter medium	Darkened at 760°F, probably due to charring of binder. Turned white as temperature rose. At 1220°F it had shrunk about 50 per cent in size.
	Aluminum separator	Melted at about 1200°F.
	Black sponge rubber gasket	Shrinks under heat but does not smoke or liquify up to 1400°F, at which temperature it becomes a white ash.

Mr. Palmer's burning tests indicated that the core of these filter units was probably the area of the highest temperatures. This would mean that in most instances the filter media and separators would probably be subjected to the highest temperatures. The gaskets, in their semiprotected location, are apparently exposed to the least heat, while the frame and adhesive would be at some intermediate temperature. If this assumption is correct, the weakest component would be the adhesive which breaks down and loses its supportive quality and probably its sealing capacity at approximately 360°F.

Although fireproof Absolute filters of limited capacity are currently available, those having sufficient capacity for large-scale applications are impractical at this time, due primarily to the technological stage of development. Nevertheless, continued development and research will in time produce filters that are sufficiently fire-resistant to confine most ventilation system fires to the filter assembly with minimal loss or damage. This will permit a considerable saving to industry by minimizing fire losses and will be a noteworthy milestone, particularly, from the standpoint of air cleaning systems for radioactive substances.

REFERENCES

1. The U. S. Atomic Energy Commission, Serious Accidents, Issue No. 110, Nov. 8, 1956.
2. The U. S. Atomic Energy Commission, Accident and Fire Prevention Information, Issue No. 6, Feb. 21, 1955.

DESIGN AND CALIBRATION OF AN IMPROVED CASCADE IMPACTOR FOR SIZE ANALYSIS OF AEROSOLS

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1 INTRODUCTION

A rapid and reliable method for determining the particle-size distribution and concentration of aerosols is essential for general aerosol and air cleaning studies. Although the physical properties and effectiveness of sprays and aerosols are determined by their particle-size distribution, accurate data on size are seldom available. Some of the numerous experimental methods of determining size distributions of aerosols are: (1) microscopic examination of particles collected on slides or in cells, (2) freezing of drops in a spray followed by sieving, (3) direct photographic methods, (4) other optical methods based on the scattering or absorption of light, (5) electronic and radioautographic techniques, and (6) impaction methods. Each of these methods has its advantages and disadvantages and none is entirely satisfactory.

The most commonly used of the six above mentioned methods is the microscopic technique. A sample of an aerosol is collected by passing a slide through the aerosol. Each individual particle on the slide is then measured. Not only is this method tedious and time consuming, but it is also biased in favor of the larger particles because the smaller particles will tend to pass around the slide.

The purpose of this paper is to describe an improved cascade impactor for the size analysis of aerosols and the methods by which it was calibrated.

2 PRINCIPLE OF THE CASCADE IMPACTOR

A cascade impactor is a device which separates aerosols into various size classes. The impactor operates on the principle that particles in a moving air stream will impact upon a slide placed in their path provided that the inertia of the particles is sufficient to overcome the drag exerted by the air stream that must pass around the slide. One of the pioneers to use this principle to classify aerosols was K. R. May.[1]

Figure 1 is a schematic drawing showing how the cascade impactor classifies particles of different sizes. As the moving particles approach the slide in the impactor, the larger